3-1974

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CARD REPORT 46T

THE CENTER FOR
AGRICULTURAL AND RURAL DEVELOPMENT
IOWA STATE UNIVERSITY • AMES, IOWA 50010

SIMULATED EFFECTS OF ALTERNATIVE POLICY AND ECONOMIC ENVIRONMENTS ON U.S. AGRICULTURE

by

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CARD REPORT 46T

March 1974

Ames, Iowa

RURAL DEVELOPMENT SPECIAL SERIES

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SIMULATED EFFECTS OF ALTERNATIVE POLICY AND ECONOMIC ENVIRONMENTS ON U.S. AGRICULTURE, 1932-1967

Historically, government price and income farm programs have been aimed at specific commodity groups. Each commodity program has its own price supports, target prices, acreage allotments, marketing quotas, or other instrumental variables. Within the framework of congressional legislation, program administrators annually announce the levels of these strategic variables for each commodity. The collection of variable levels for all programs represents one point in a set of possible combinations. The level of each government policy parameter or variable not only affects a particular commodity but also related agricultural commodities, the entire agricultural sector, and the economy as a whole.

Past econometric investigations have attempted to analyze the impact of government policies in the aggregate [12, 17, 33] or on specific commodities [4, 20, 28]. The number of government program variables and allowances for substitution between commodities (in the form of resource use or final demand) are necessarily limited in these studies. An analysis of the effects of a change in a commodity-specific policy instrument on resource use, production, utilization and resource returns on that commodity, related commodities, and aggregate agriculture requires integrating the agricultural factor and commodity markets. This study is an attempt at such an integration. It provides the results of 17 simulations. The conditions simulated are: (a) the removal of government price and income support programs, (b) increases in input prices, (c) restrictions on production elasticities, (d) variations in commodity support activities, and (e) limitations on acreages.

The simulation model results incorporate specific government policy variables for major agricultural commodities and, where feasible, permits interactions among commodities. This research involves two phases. First, sectorial models are developed for livestock, feed grains, wheat, soybeans, cotton, and tobacco. Each sectorial model causally links resource use, production, price, final demand, and gross receipts for the particular commodity. The policy variables incorporated in equation specifications include price supports, acreage diversions or allotments, and direct government payments. Second, simulation experiments are run with the model to determine the model's validity and to analyze the impacts of alternative levels of government policy, prices, and technology.

Overview of the Model

The agricultural economy is disaggregated into commodity groups for which submodels are established. The commodity groups are livestock, feed grains, wheat, soybeans, cotton, and tobacco. The relations in each submodel sequentially depict the commodity's yearly production cycle from acreage planted (in the crop models) to the level of resource use, production, price, commodity disposition, and finally to gross income. This sequential ordering attempts to capture the recursive nature of agricultural production. The submodels, or blocks of commodity equations, are

Data

Time series data for many of the commodity resource demand variables are not published. The commodity input series was developed from cost and returns studies, input-output studies, published and unpublished data from the U.S. Department of Agriculture, discussions with officials of the USDA's Farm Production Economics Division, and the national trends of the aggregate input series.[1] Published data for the remaining variables are available from USDA.

Estimated Equations

The estimated equations and identities for each of the six commodity submodels are presented in tables 2 through 7. Space limitations prevent a discussion of each estimated relation. Such an analysis is given, however, in Ray [23]. In addition to the six commodity submodels, identities are included to aggregate variable estimates for the separate commodities into national estimates. Variable levels of commodities not in the model are treated as given data and are included in national identities. These identities are presented in table 8.

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[1]For example, the commodity fertilizer data series was developed from survey and census data published by the National Fertilizer Association [8] and the U.S. Department of Agriculture [15, 16] for the years 1927, 1938, 1947, 1954, 1959, and 1964. Estimated tonnages of nitrogen, phosphoric acid, and potash applied to model crops were converted to pounds per acre. Linear interpolations of the per-acre estimates were made for intervening years. The sum over all crops of per-acre application times acreage was compared to published aggregate consumption for each nutrient for the corresponding year. Application rates were uniformly adjusted to reconcile differences. Average 1947-1949 prices for the separate nutrients were used to aggregate nutrient usage by crop. Non-nitrogen fertilizer distribution by crops was used to allocate national lime expense to the individual crops. See Ray [23] for a complete documentation of data sources and derivations and for time series lists of all data.

brought together to form the overall simulation model in a manner that preserves the recursive structure. The submodel organization permits the explicit inclusion of appropriate government policy variables for individual commodities. The primary and secondary effects of a change in a commodity policy variable are traceable through the equations of the relevant commodity, related commodities, and total agriculture.

The general structure of each commodity submodel is as follows: (a) acreage and resource demand variables are functions of previous year prices and gross incomes of the commodity under consideration and related commodities, acreage allotments or diversions, previous year resource prices, and resource demand shifters; (b) commodity production is dependent on the quantity and productivity of resources committed to the commodity; (c) commodity supply depends on production, carry-in, and imports; (d) commodity price is dependent on the price support level, the discrepancy between current year supply and previous year domestic and foreign utilization, and other variables; (e) commodity demands are functions of current year prices of the commodity and related commodities and demand shifter variables; and (f) commodity gross income is dependent on current year commodity price, productions, and government payments.

Figure 1 is a visual presentation of the model's functional relationships. The pie-shaped sections represent the six commodity submodels. The variable code names are composed of two parts. The first letter (or letters) identifies the commodity or aggregate name. The remainder of the code identifies the specific variable being measured. Variable definitions are

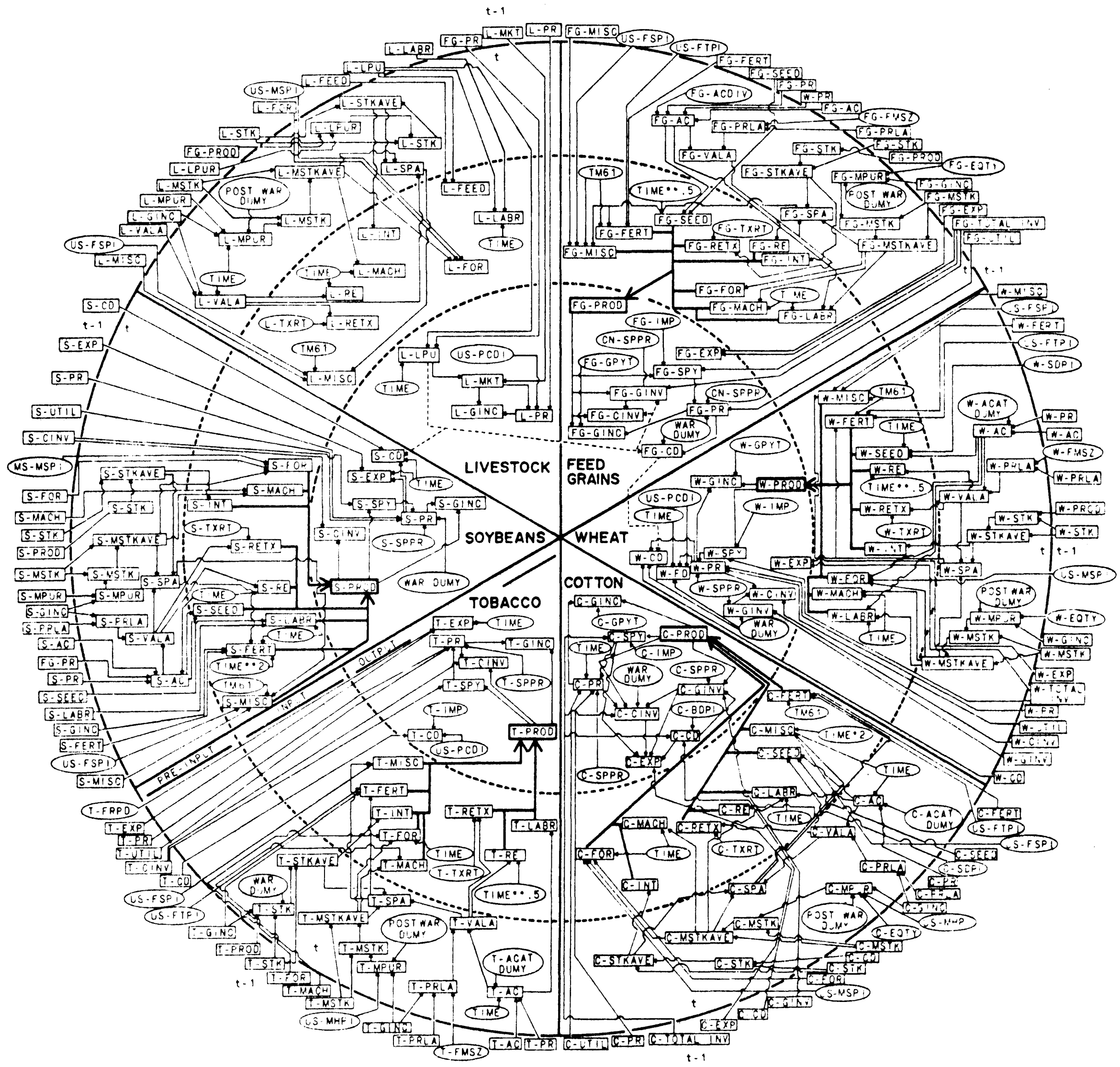

Figure 1. A schematic diagram of the simulation model

listed in table 1. Dependent variables in the figure are enclosed in rectangles; exogenous variables are surrounded by ovals. Causal ordering is indicated by the direction of the arrow. Lagged values of variables appear outside the perimeter of the circle. The broken circles partition the current dependent variables into three subsets. The area bounded by the circle perimeter and outer dotted circle contains pre-input variables; the area between the broken circles contains input variables; and the output variables appear within the inner broken circle.[1] This categorization of variables into three groups facilitates presentation of the relationships and brings out the recursive aspects of the submodels.

The pre-input sections of the submodels contain equations to estimate acreage (in the crop submodels), ending calendar year stocks of machinery and commodities, the value of land and buildings used in producing the commodity, and total value of physical assets committed to the commodity. Other equations are included to aid in generating the stock estimates; land price equations provide estimates for the value of land relations; estimates of machinery purchases are utilized in the machinery stock equations.

Equations in the input sections of the submodels use information generated in the corresponding commodity's pre-input section along with other data to estimate commodity input demand levels. The input categories included in this section correspond closely to those used by the USDA's

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[1] This categorization of variables is similar to variable groupings used by Tyner and Tweeten [33] in their aggregate model of agriculture.

Table 1. Definitions of variable code names used in simulator model[a]

Variable code name	Definition	Variable code name	Definition	Variable code name	Definition
AC	Acreage (million acres)	INT	Interest on farmer held commodity inventories (million 1947-49 dollars)	SDPI	Index of seed prices deflated by the implicit GNP deflator (1947-49 = 100)
LPUR	Livestock purchased by farmers (million 1947-49 dollars)	RETX	Real estate taxes (million 1947-49 dollars)	FMSZ	Index of acres per farm (1947-49 = 100)
STK	Ending calendar year commodity stock on farms (million 1947-49 dollars)	PROD	Crop production (FG, million tons; W and S, million bushels; C million bales; and T, million pounds)	EQTY	Equity ratio defined as the value of real estate divided by mortgage debt on that real estate
STKAVE	Average of beginning and ending calendar year commodity stock on farms (million 1947-49 dollars)	LPU	Livestock production units (million units)	IMP	Crop year imports (Same units as production)
MPUR	Machinery purchases (million 1947-49 dollars)	MKT	Index of livestock marketings (1947-49 = 100)	MHPI	Index of machinery price deflated by GNP deflator (1947-49 = 100)
MSTK	Ending calendar year stock of machinery on farms (million 1947-49 dollars)	SPY	Beginning crop year supplies defined as the sum of production, carry-in stocks and imports.	FTPI	Index of fertilizer price deflated by GNP deflator (1947-49 = 100)
MSTKAVE	Average of ending and beginning calendar year machinery stock on farms (million 1947-49 dollars)	PR	Average crop year price received by farmers deflated by the implicit GNP deflator. (L, index 1947-49 = 100: FG, dollars per ton; W and S, dollars per bushel; C and T, dollars per pound)	MSPI	Index of motor supplies price deflated by GNP deflator (index 1947-49 = 100)
PRLA	Index of price of land and buildings per acre (index 1947-49 = 100)	CD	Total domestic crop year demand for all uses, except wheat in which only nonfood demand is included (Same units as production)	FSPI	Index of farm supplies price deflated by GNP deflator (index 1947-49 = 100)
VALA	Value of farmland and buildings (million 1947-49 dollars)	FD	Crop year demand for wheat as food (million bushels)	PCDI	Per capita disposable income deflated by GNP deflator (1947-49 dollars)
SPA	Stock of physical assets defined as the sum of STKAVE, MSTKAVE and VALA (million 1947-49 dollars)	GINV	Government ending crop year inventory (Same units as production)	BDPI	Index of the price of broadwoven cloth deflated by GNP deflator (index 1947-49 = 100)
FERT	Fertilizer and lime expense (million 1947-49 dollars)	CINV	Commercial ending crop year inventory (Same units as production)	TIME	Trend variable with 1930 = 1.0
SEED	Purchased plus home-grown seed for individual crops (million 1947-49 dollars)	EXP	Crop year exports (Same units as production)	Time**2	Square of the TIME variable
FEED	Purchased livestock feed (million 1947-49 dollars)	GINC	Cash receipts and government payments deflated by the implicit GNP deflator (million 1947-49 dollars)	Time**.5	Square root of the TIME variable
LABR	Man-hour requirements (million man-hours)	TXRT	Tax rate per dollar value of land and buildings	WARDUMY	Dummy variable for World War II with 1.0's for the years 1942-47
MACH	Machinery interest and depreciation (million 1947-49 dollars)	SPPR	Average support price levels deflated by the implicit GNP deflator (Same units as price)	POSTWARDUMY	Dummy variable with 1.0's for years 1948-52
RE	Real estate expense including interest on land and farm buildings and depreciation, repairs and maintenance on farm buildings (million 1947-49 dollars)	GPYT	Government payments deflated by the implicit GNP deflator (million 1947-49 dollars)	FRPD	Calendar year production of tobacco in all countries excluding the United States (million pounds)
FOR	Machinery fuel, oil and repairs expense (million 1947-49 dollars)	ACATDUMY	Acreage allotment dummy with 1.0's in years allotments were in effect		
MISC	Miscellaneous expenses including pesticides, small hand tools, binding materials, electricity, telephone, etc. (million 1947-49 dollars)	ACDIV	Acreage diverted from production (million acres)		

[a]Prescripts on variable code names in Figure 1 refer to commodity categories: livestock (L), feed grains (FG), wheat (W), soybeans (S), cotton (C), tobacco (T), other crops (O) and all commodities (US).

Farm Production Economics Division for calculating aggregate input costs [18]. Current or monoperiod factors of production included in the input sections are fertilizer and lime, seed, labor and machinery operating expenses. Other equations estimate the flow of services from, or the opportunity costs of, polyperiod or durable resources. Machinery expense (interest and depreciation), real estate expense, interest on commodity stocks, and real estate taxes fall into this latter group of inputs.

The final set of categories, or output sections, contains production functions, supply identities, price equations, commodity utilization and ending crop year inventory equations, and gross income equations. The livestock output section includes equations to estimate the number of livestock production units fed, livestock marketings, the price of livestock, and gross receipts from the sale of livestock.

In addition, the simulator contains a set of identities which sum variable estimates for the separate commodities into national estimates. Variable levels of commodities not in the model are treated as exogenous, or given, data and are included in the identities.

Some Comments on Equation Specification

Resource use equations

Statis firm theory relates the levels of resource use to their prices and productivities and to commodity prices. This theory must be modified to estimate resource use in the real world where farmer capital is limited and response to price and productivity changes is less than instantaneous. Because of the biological lag in agriculture between resource commitment and realized output and price, resource equations are specified as functions of previous year input and commodity prices. Previous year gross incomes, the ratios of assets to liabilities, and measures of asset stocks are included as demand shifters to represent the influence of the availability of capital funds. The income variables indicate changes in the availability of internal funds, while other variables serve as measures of borrowing capacity. The distribution of income, liabilities, and assets among producers has an important influence on aggregate resource demands. Because of the lack of more precise data, however, aggregate measures of these financial variables are used. Since time is required to adjust resource use to changing prices, input productivities, and capital constraints, many of the resource use equations are formulated with a geometrically distributed lag structure.

Production functions

Cobb-Douglas production functions are estimated for each crop in the models for each of four time periods. Input variables appearing in the input section of the crop's submodel are the determinants of that crop's production level. The functions are not estimated directly but are constructed after separate estimation of each individual partial production elasticity for each of the four time periods. Factor share data are used to compute the partial input production elasticities. Factor shares are valid estimates of partial production elasticities only if economic equilibrium prevails. An adjustment model suggested by Tyner and Tweeten [32] is used to correct the factor share estimates for divergence from the equilibrium position. In estimation, dummy variables are used to permit the separately estimated partial production elasticities to change over the observation period. The dummy variable structure used results in crop production functions for 1930-39, 1940-49, 1950-58, and 1959-67.

Price and demand equations

The specification of the commodity demand and price equations is based on a recursive interpretation of market forces. Given the technology level, commodity production (and for the most part commodity supply) is determined by the prices of output and resources of the preceding year. The relative size of the predetermined supply determines the current commodity price, and the quantity demanded is a function of current price. The relative size of current supply can be measured in relation to the quantity demanded for domestic and foreign use the preceding year. Crop price equations were specified as functions of last year's price, the difference between current supply and last year's utilization, and the commodity's average support price.

Separate relations estimate domestic demand, exports, and ending year inventories for each crop as functions of current year price and relevant demand shifter variables, such as the number of livestock production units and per capita consumer income.

Econometric Considerations

The recursive structure of the model simplified the simulation procedure, and under certain conditions, parameter estimates can be obtained with ordinary least squares applied to one equation at a time. The conditions that must be satisfied to obtain consistent and efficient parameter estimates with least squares are very stringent, however. Two of the more important conditions are: (a) the contemporary variance-covariance matrix of the model disturbances must be diagonal, and (b) there must be no correlation of successive equation disturbances. That is, the disturbances must be nonautocorrelated. Since these are rather exacting conditions, other estimation procedures were also used. Two-stage least squares are used to estimate equations with more than one dependent variable and, hence, allow for a generalized variance-covariance matrix. The second condition is made less restrictive by allowing the successive error terms to follow a first-order autoregressive scheme. Fuller's and Martin's [9, 10] autoregressive least squares procedure is applied to equations with one dependent variable. A method called autoregressive two-stage least squares is used for equations with more than one dependent variable.[1] Generally, the coefficient estimates of the autoregressive techniques are used in the simulation model if the autocorrelative coefficient estimate is significantly different from zero. All relations are estimated with annual time series data for 1930-67.

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[1]The mechanics of this estimation technique are detailed in Ray [23].

The Simulation Procedure

The estimated equations and identities in tables 2 through 8 describe the functioning of the agricultural economy. Econometric simulation involves translating the relationships into a computer language, such as FORTRAN, and "operating" this model of the real agricultural economy. In other words, the collection of separate relationships is treated as an integrated model and "put in motion."

The mechanics of the simulation process are the simplest when the real economy is represented by a recursive econometric model[1], such as our agricultural model. The computer program is constructed to solve each equation sequentially. Information generated from solving an equation may be used in succeeding equations. When each of the equations for each of the submodels has been solved, one time period for the economy has been described, and the computer returns to the first equation to begin generating information for the next year. In this and remaining years, variable levels may be included that were estimated in previous years.

Simulation provides the social scientist with a "laboratory". Experiments that would be too costly or completely impossible to

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[1]A model is recursive if its equations can logically be arranged so each dependent variable (variables whose values are explained by model) is a function of predetermined variables (variables whose values are determined outside the model or whose values are given by past values of dependent variables) and variables that have been treated as dependent earlier in the model.

Table 2. Estimated Equations for the Livestock Submodel [a]

Pre-input Section

$$\text{L-LPUR}_t = -205.7 + \underset{(1.7789)}{4.5720}\ \text{FG-PROD}_{t-1} + \underset{(.0698)}{.8586}\ \text{L-PUR}_{t-1}$$

LS $\quad d = 2.43 \quad R^2 = .901 \quad MSE = 19{,}038.$

$$\text{L-STK}_t = 3780.9 + \underset{(.2971)}{.8756}\ \text{L-PUR}_t + \underset{(.1277)}{.6105}\ \text{L-STK}_{t-1}$$

2SLS $\quad d = 1.65 \quad R^2 = .901 \quad MSE = 315{,}211.$

$$\text{L-STKAVE}_t = (\text{L-STK}_{t-1} + \text{L-STK}_t)\ /2$$

$$\text{L-MPUR}_t = .3125 + \underset{(15.9188)}{53.5906}\ \text{POSTWARDUMY} + \underset{(.0021)}{.0049}\ \text{L-GINC}_{t-1} = \underset{(.6869)}{2.3647}\ \text{TIME} + \underset{(.1429)}{.2929}\ \text{L-MPUR}_{t-1}$$

LS $\quad d = 1.99 \quad R^2 = .907 \quad MSE = 514.43$

$$\text{L-MSTK}_t = -37.532 + \underset{(.1947)}{1.2174}\ \text{L-MPUR}_t + \underset{(.0300)}{.8721}\ \text{L-MSTK}_{t-1}$$

2SLS $\quad d = 1.75 \quad R^2 = .989 \quad MSE = 2{,}356.7$

$$\text{L-MSTKAVE}_t = (\text{L-MSTK}_{t-1} + \text{L-MSTK}_t)\ /2$$

$$\text{L-VALA}_t = -16.633 + \underset{(.0910)}{.0996}\ \text{L-GINC}_{t-1} = \underset{(63.4461)}{108.0093}\ \text{TIME} + \underset{(.0608)}{.9246}\ \text{L-VALA}_{t-1}$$

ALS $\quad \rho = \underset{(.1467)}{-.6032} \quad d = 1.89 \quad R^2 = .971 \quad MSE = 2{,}869{,}794.$

$$\text{L-SPA}_t = \text{L-STKAVE}_t + \text{L-MSTKAVE}_t + \text{L-VALA}_t$$

Input Section

$$\text{L-FEED}_t = -975.282 + \underset{(4.4477)}{9.1596}\ \text{L-LPU}_{t-1} + \underset{(.0698)}{.8586}\ \text{L-LPUR}_{t-1}$$

ALS $\quad \rho = \underset{(.1728)}{.0279} \quad d = 2.04 \quad R^2 = .983 \quad MSE = 60{,}799.$

$$\text{L-LABR}_t = 498.05 + \underset{(2.0379)}{12.5193}\ \text{L-LPU}_{t-1} \underset{(111.0861)}{-242.5923}\ \text{TIME} + \underset{(.1179)}{.2000}\ \text{L-LABR}_{t-1}$$

ALS $\quad \rho = \underset{(.0369)}{.9468} \quad d = 2.02 \quad R^2 = .995 \quad MSE = 7{,}350.1$

(continued)

(Input Section continued)

$$\text{L-MACH}_t = 12.468 + \underset{(.0067)}{.1995}\ \text{L-MSTKAVE}_t - \underset{(.2682)}{.7522}\ \text{TIME}$$

2SLS $\quad d = 1.45 \quad R^2 = .995 \quad MSE = 33.1$

$$\text{L-RE}_t = 366.672 + \underset{(.0011)}{.0434}\ \text{L-VALA}_t + \underset{(.8990)}{8.1235}\ \text{TIME}$$

ATS-2 $\quad \rho = \underset{(.0844)}{-.3260} \quad d = .619 \quad R^2 = .996 \quad MSE = 999.379$

$$\text{L-FOR}_t = 226.23 + \underset{(.0269)}{.0128}\ \text{L-MSTKAVE}_t - \underset{(.6245)}{1.4906}\ \text{US-MSPI}_{t-1} + \underset{(.1302)}{.7905}\ \text{L-FOR}_{t-1}$$

2SLS $\quad d = 2.38 \quad R^2 = .990 \quad MSE = 251.0$

$$\text{L-MISC}_t = 168.1829 + \underset{(.0020)}{.0169}\ \text{L-SPA}_t - \underset{(1.6277)}{5.3965}\ \text{US-FSPI}_{t-1} + \underset{(7.2887)}{18.1500}\ \text{TM61} + \underset{(.1033)}{.1712}\ \text{L-MISC}_{t-1}$$

ALS $\quad \rho = \underset{(.1715)}{.4253} \quad d = 1.78 \quad R^2 = .993 \quad MSE = 861.53$

$$\text{L-INT}_t = 46.878 + \underset{(.0030)}{.0563}\ \text{L-STKAVE}_t$$

ATS-2 $\quad \rho = \underset{(.1484)}{.3134} \quad d = 1.45 \quad R^2 = .958 \quad MSE = 421.71$

$$\text{L-RETX}_t = \text{L-VALA}_t * \text{L-TXRT}_t$$

Output Section

$$\text{L-LPU}_t = 37.998 - \underset{(.0999)}{.0795}\ \text{FG-PR}_{t-1} + \underset{(.2695)}{.6591}\ \text{TIME} + \underset{(.1113)}{.7390}\ \text{L-LPU}_{t-1}$$

LS $\quad d = 1.40 \quad R^2 = .936 \quad MSE = 54.903$

$$\text{L-MKT}_t = -30.325 + \underset{(.1008)}{.4038}\ \text{L-LPU}_t + \underset{(.1005)}{.6255}\ \text{L-MKT}_{t-1}$$

2SLS $\quad d = 1.99 \quad R^2 = .980 \quad MSE = 16.48$

$$\text{L-PR}_t = 13.856 - \underset{(.2252)}{.8726}\ \text{L-MKT}_t + \underset{(.0187)}{.0640}\ \text{US-PCDI} + \underset{(.1616)}{.2432}\ \text{L-PR}_{t-1}$$

ALS $\quad \rho = \underset{(.1184)}{.8042} \quad d = 1.81 \quad R^2 = .890 \quad MSE = 31.27$

$$\text{L-GINC}_t = 99.539 + \underset{(.0278)}{1.6019}\ \text{L-MKT}_t * \text{L-PR}_t$$

ALS $\quad \rho = \underset{(.1365)}{.6287} \quad d = 1.51 \quad R^2 = .998 \quad MSE = 27{,}978.$

[a]Coefficient standard errors are in parentheses. The estimation technique used to estimate parameters are indicated as LS (least squares), ALS (autoregressive least squares), 2SLS(two stage least square) and ATS (autoregressive two stage least squares). The first order autoregressive coefficient is reported as ρ. The Durbin-Watson d statistic and equation mean square error (MSE) are also reported.

Table 3. Estimated Equations for the Feed Grain Submodel[a]

Pre-input Section

$$\text{FG-AC}_t = 123.44 + \underset{(.2117)}{.5637}\ \text{FG-PR}_{t-1} - \underset{(6.6271)}{22.5082}\ \text{W-PR}_{t-1} - \underset{(.2130)}{1.0379}\ \text{FG-ACDIV}_t + \underset{(.1418)}{.1925}\ \text{FG-AC}_{t-1}$$

LS $\quad d = 1.98 \quad R^2 = .797 \quad MSE = 61.213$

$$\text{FG-STK}_t = -34.22 + \underset{(2.9274)}{41.7228}\ \text{FG-PROD}_{t-1}$$

ALS $\quad \rho = \underset{(.1515)}{-.4845} \quad d = 2.04 \quad R^2 = .723 \quad MSE = 449,147.$

$$\text{FG-STKAVE}_t = (\text{FG-STK}_{t-1} + \text{FG-STK}_t)/2$$

$$\text{FG-MPUR}_t = 88.8782 + \underset{(86.0408)}{284.1584}\ \text{POSTWARDUMY} + \underset{(10.5967)}{39.4036}\ \text{FG-EQTY}_{t-1} + \underset{(.0445)}{.1025}\ \text{FG-GINC}_{t-1}$$

ALS $\quad \rho = \underset{(.1624)}{.4242} \quad d = 1.87 \quad R^2 = .871 \quad MSE = 12,344.$

$$\text{FG-MSTK}_t = -18.351 + \underset{(.1747)}{.9295}\ \text{FG-MPUR}_t + \underset{(.0450)}{.7980}\ \text{FG-MSTK}_{t-1}$$

2SLS $\quad d = 2.43 \quad R^2 = .963 \quad MSE = 46,436.$

$$\text{FG-MSTKAVE}_t = (\text{FG-MSTK}_{t-1} + \text{FG-MSTK}_t)/2$$

$$\text{FG-PRLA}_t = -142.33 + \underset{(.4877)}{1.8361}\ \text{FG-FMSZ}_{t-1} + \underset{(.1237)}{.6411}\ \text{FG-PRLA}_{t-1}$$

LS $\quad d = 2.23 \quad R^2 = .964 \quad MSE = 96.688$

$$\text{FG-VALA}_t = -.4778 + \underset{(.0002)}{.9194}\ \text{FG-PRLA}_t * \text{FG-AC}_t$$

ATS $\quad d = 1.90 \quad R^2 = .999 \quad MSE = 41.519$

$$\text{FG-SPA}_t = \text{FG-STKAVE}_t + \text{FG-MSTKAVE}_t + \text{FG-VALA}_t$$

Input Section

$$\text{FG-FERT}_t = 114.46 + \underset{(.0041)}{.0045}\ \text{FG-SPA}_t - \underset{(.6957)}{1.3184}\ \text{US-FTPI}_{t-1} + \underset{(8.0763)}{30.6667}\ \text{TM61} + \underset{(.1056)}{.8550}\ \text{FG-FERT}_{t-1}$$

2SLS $\quad d = 2.33 \quad R^2 = .995 \quad MSE = 863.54$

$$\text{FG-SEED}_t = -135.311 + \underset{(.1822)}{.8846}\ \text{FG-AC}_t + \underset{(3.3282)}{14.8038}\ \text{TIME**.5} + \underset{(.0940)}{.5739}\ \text{FG-SEED}_{t-1}$$

ALS $\quad \rho = \underset{(.1618)}{-.4754} \quad d = 1.97 \quad R^2 = .910 \quad MSE = 99.314$

$$\text{FG-LABR}_t = 1761.9 + \underset{(3.9203)}{13.1434}\ \text{FG-AC}_t - \underset{(.0576)}{.2800}\ \text{FG-MSTKAVE}_t - \underset{(8.3346)}{45.1842}\ \text{TIME}$$

ATS-1 $\quad d = 1.04 \quad R^2 = .970 \quad MSE = 29,439.$

$$\text{FG-MACH}_t = 47.014 + \underset{(.0086)}{.2635}\ \text{FG-MSTKAVE}_t - \underset{(.8233)}{2.5618}\ \text{TIME}$$

2SLS $\quad d = 2.30 \quad R^2 = .989 \quad MSE = 824.48$

$$\text{FG-RE}_t = 2.820 + \underset{(.0009)}{.0510}\ \text{FG-VALA}_t$$

ALS $\quad \rho = \underset{(.0892)}{.8746} \quad d = 2.01 \quad R^2 = .997 \quad MSE = 108.84$

$$\text{FG-FOR}_t = 30.864 + \underset{(.0311)}{.1043}\ \text{FG-MSTKAVE}_t$$

ALS $\quad \rho = \underset{(.0468)}{.9242} \quad d = 2.08 \quad R^2 = .977 \quad MSE = 1426.0$

$$\text{FG-MISC}_t = 181.36 + \underset{(.0017)}{.0099}\ \text{FG-SPA}_t - \underset{(.6646)}{2.0179}\ \text{US-FSPI}_{t-1} + \underset{(2.7266)}{12.0770}\ \text{TM61} + \underset{(.1298)}{.3018}\ \text{FG-MISC}_{t-1}$$

ATS $\quad d = 2.47 \quad R^2 = .989 \quad MSE = 220.93$

$$\text{FG-INT}_t = -3.6203 + \underset{(.0019)}{.0622}\ \text{FG-STKAVE}_t$$

ALS $\quad \rho = \underset{(.1442)}{-.5441} \quad d = 2.14 \quad R^2 = .936 \quad MSE = 403.15$

$$\text{FG-RETX}_t = \text{FG-VALA}_t * \text{FG-TXRT}_t$$

Output Section

$$\text{FG-PROD}_{(1932-39)} = .0632\ \text{FG-FERT}_t^{.03243}\ \text{FG-SEED}_t^{.03939}\ \text{FG-LABR}_t^{.28743}\ \text{FG-MACH}_t^{.20900}\ \text{FG-RE}_t^{.24063}\ \text{FG-FOR}_t^{.14243}\ \text{FG-MISC}_t^{.06999}\ \text{FG-INT}_t^{.04776}\ \text{FG-RETX}_t^{.05665}$$

$$\text{FG-PROD}_{(1940-49)} = 1.07778\ \text{FG-FERT}_t^{.04486}\ \text{FG-SEED}_t^{.03434}\ \text{FG-LABR}_t^{.189[illegible]}\ \text{FG-MACH}_t^{.12227}\ \text{FG-RE}_t^{.10796}\ \text{FG-FOR}_t^{.11465}\ \text{FG-MISC}_t^{.03860}\ \text{FG-INT}_t^{.04002}\ \text{FG-RETX}_t^{.01888}$$

$$\text{FG-PROD}_{(1950-58)} = .15513\ \text{FG-FERT}_t^{.08321}\ \text{FG-SEED}_t^{.03903}\ \text{FG-LABR}_t^{.12936}\ \text{FG-MACH}_t^{.28726}\ \text{FG-RE}_t^{.17451}\ \text{FG-FOR}_t^{.18028}\ \text{FG-MISC}_t^{.06271}\ \text{FG-INT}_t^{.04156}\ \text{FG-RETX}_t^{.03357}$$

$$\text{FG-PROD}_{(1959-67)} = .06593\ \text{FG-FERT}_t^{.13257}\ \text{FG-SEED}_t^{.03479}\ \text{FG-LABR}_t^{.08478}\ \text{FG-MACH}_t^{.36219}\ \text{FG-RE}_t^{.29539}\ \text{FG-FOR}_t^{.15898}\ \text{FG-MISC}_t^{.1000}\ \text{FG-INT}_t^{.04558}\ \text{FG-RETX}_t^{.05673}$$

$$\text{FG-SPY}_t = \text{FG-PROD}_t + \text{FG-GINV}_{t-1} + \text{FG-CINV}_{t-1} + \text{FG-IMP}_t$$

$$\text{FG-PR}_t = 19.838 + \underset{(3.0248)}{21.8219}\ \text{CN-SPPR}_t - \underset{(.0432)}{.2051}\ (\text{FG-SPY}_t - \text{FG-UTIL}_{t-1}) + \underset{(2.9788)}{9.7044}\ \text{WARDUMY}$$

ALS $\quad \rho = \underset{(.1567)}{.0828} \quad d = 1.46 \quad R^2 = .852 \quad MSE = 27.701$

$$\text{FG-CD}_t = -10.795 + \underset{(.0356)}{.7230}\ \text{L-LPU}_t - \underset{(.1118)}{.2824}\ \text{FG-PR}_t + \underset{(3.2951)}{6.6410}\ \text{WARDUMY}$$

ATS $\quad \rho = \underset{(.1211)}{.1027} \quad d = 1.54 \quad R^2 = .959 \quad MSE = 22.178$

$$\text{FG-GINV}_t = 11.089 + \underset{(.1448)}{.4859}\ \text{FG-PROD}_t + \underset{(.1437)}{.9363}\ (\text{FG-GINV}_{t-1} + \text{FG-CINV}_{t-1}) + \underset{(5.8884)}{6.9024}\ \text{CN-SPPR}_t - \underset{(.1642)}{.5312}\ \text{L-LPU}_t$$

ATS $\quad \rho = \underset{(.1843)}{.5264} \quad d = 1.95 \quad R^2 = .949 \quad MSE = 30.970$

$$\text{FG-CINV}_t = 2.0247 - \underset{(.0187)}{.1533}\ \text{FG-GINV}_t + \underset{(.0465)}{.1802}\ \text{FG-PROD}_t - \underset{(.0423)}{.0499}\ \text{L-LPU}_t$$

2SLS $\quad d = 1.47 \quad R^2 = .818 \quad MSE = 2.427$

$$\text{FG-EXP}_t = -.504 + \underset{(.0174)}{.0464}\ \text{FG-INV}_{t-1} + \underset{(.0542)}{.9217}\ \text{FG-EXP}_{t-1}$$

ALS $\quad \rho = \underset{(.1551)}{-.5074} \quad d = 2.06 \quad R^2 = .930 \quad MSE = 4.83$

$$\text{FG-GINC}_t = 64.607 + \underset{(.0508)}{.1609}\ \text{FG-PROD}_t * \text{FG-PR}_t + \underset{(.1835)}{.8564}\ \text{FG-GYPT}_t$$

ATS $\quad \rho = \underset{(.0398)}{.9746} \quad d = 2.85 \quad R^2 = .978 \quad MSE = 16,454.$

[a]Coefficient standard errors are in parentheses. The estimation technique used to estimate parameters are indicated as LS (least squares), ALS (autoregressive least squares), 2SLS (two stage least square) and ATS (autoregressive two stage least squares). The first order autoregressive coefficient is reported as ρ. The Durbin-Watson d statistic and equation mean square error (MSE) are also reported.

Table 4. Estimated Equations for Wheat Submodel[a]

Pre-input Section

$$\text{W-AC}_t = 26.968 + \underset{(2.2302)}{5.1321}\,\text{W-PR}_{t-1} - \underset{(1.7248)}{7.0059}\,\text{W-ACATDUMY} + \underset{(.1011)}{.4722}\,\text{W-AC}_{t-1}$$

LS $\quad d = 1.69 \quad R^2 = .738 \quad \text{MSE} = 22.656$

$$\text{W-STK}_t = 155.50 + \underset{(.1853)}{.1911}\,\text{W-PROD}_{t-1} + \underset{(.2226)}{.5444}\,\text{W-STK}_{t-1}$$

LS $\quad d = 2.07 \quad R^2 = .524 \quad \text{MSE} = 20{,}645.$

$$\text{W-STKAVE}_t = (\text{W-STK}_{t-1} + \text{W-STK}_t)\,/2$$

$$\text{W-MPUR}_t = 5.111 + \underset{(24.7713)}{37.2151}\,\text{POSTWARDUMY} + \underset{(2.9762)}{7.6931}\,\text{W-EQTY}_{t-1} + \underset{(.0216)}{.0539}\,\text{W-GINC}_{t-1}$$

ALS $\quad \rho = \underset{(.1837)}{.4582} \quad d = 1.99 \quad R^2 = .860 \quad \text{MSE} = 1{,}007.8$

$$\text{W-MSTK}_t = 9.849 + \underset{(.3298)}{.8657}\,\text{W-MPUR}_t + \underset{(.0746)}{.8401}\,\text{W-MSTK}_{t-1}$$

ATS-1 $\quad d = 2.37 \quad R^2 = .928 \quad \text{MSE} = 9{,}535.1$

$$\text{W-MSTKAVE}_t = (\text{W-MSTK}_{t-1} + \text{W-MSTK}_t)\,/2$$

$$\text{W-PRLA}_t = -61.535 + \underset{(.3271)}{1.1481}\,\text{W-FMSZ}_{t-1} + \underset{(.1321)}{.5384}\,\text{W-PRLA}_{t-1}$$

LS $\quad d = 2.20 \quad R^2 = .864 \quad \text{MSE} = 165.59$

$$\text{W-VALA}_t = 2.7804 + \underset{(.0003)}{.6801}\,\text{W-AC}_t * \text{W-PRLA}_t$$

2SLS $\quad d = 2.42 \quad R^2 = .999 \quad \text{MSE} = 9.00$

$$\text{W-SPA}_t = \text{W-STKAVE}_t + \text{W-MSTKAVE}_t + \text{W-VALA}_t$$

Input Section

$$\text{W-FERT}_t = 95.945 + \underset{(.0039)}{.0041}\,\text{W-SPA}_t - \underset{(.3338)}{.8255}\,\text{US-FTPI}_{t-1} + \underset{(2.5878)}{9.1423}\,\text{TM61} + \underset{(.1313)}{.6008}\,\text{W-FERT}_{t-1}$$

2SLS $\quad d = 1.96 \quad R^2 = .969 \quad \text{MSE} = 205.77$

$$\text{W-SEED}_t = 17.090 + \underset{(.1934)}{2.2897}\,\text{W-AC}_t - \underset{(.0939)}{.0650}\,\text{W-SDPI}_{t-1} + \underset{(.1276)}{.1555}\,\text{TIME}$$

ATS-1 $\quad d = 2.01 \quad R^2 = .889 \quad \text{MSE} = 50.37$

$$\text{W-LABR}_t = 130.23 + \underset{(.7150)}{6.4774}\,\text{W-AC}_t - \underset{(.0442)}{.1713}\,\text{W-MSTKAVE}_t - \underset{(1.4935)}{5.8608}\,\text{TIME}$$

ALS $\quad \rho = \underset{(.1442)}{.3405} \quad d = 2.02 \quad R^2 = .975 \quad \text{MSE} = 594.9$

$$\text{W-MACH}_t = 7.6711 + \underset{(.0123)}{.2403}\,\text{W-MSTKAVE}_t - \underset{(.3789)}{1.0459}\,\text{TIME}$$

2SLS $\quad d = 2.24 \quad R^2 = .978 \quad \text{MSE} = 127.25$

$$\text{W-RE}_t = 15.362 + \underset{(.0015)}{.0495}\,\text{W-VALA}_t + \underset{(1.1360)}{2.9174}\,\text{TIME} ** .5$$

ATS-1 $\quad d = .53 \quad R^2 = .988 \quad \text{MSE} = 48.537$

$$\text{W-FOR}_t = 200.412 - \underset{(.4073)}{2.5492}\,\text{US-MSPI}_{t-1} + \underset{(.0197)}{.1225}\,\text{W-MSTKAVE}_t + \underset{(.3508)}{1.7601}\,\text{W-AC}_t$$

ATS-2 $\quad \rho = \underset{(.1399)}{.2435} \quad d = 1.74 \quad R^2 = .976 \quad \text{MSE} = 205.62$

$$\text{W-MISC}_t = 115.79 + \underset{(.0020)}{.0111}\,\text{W-SPA}_t - \underset{(.2384)}{1.0869}\,\text{US-FSPI}_{t-1} + \underset{(1.1261)}{5.5460}\,\text{TM61} + \underset{(.1380)}{.2447}\,\text{W-MISC}_{t-1}$$

ATS-1 $\quad d = 2.21 \quad R^2 = .984 \quad \text{MSE} = 38.138$

$$\text{W-INT}_t = -.5146 + \underset{(.0048)}{.0623}\,\text{W-STKAVE}_t$$

2SLS $\quad d = 2.34 \quad R^2 = .852 \quad \text{MSE} = 22.75$

$$\text{W-RETX}_t = \text{W-VALA}_t * \text{W-TXRT}_t$$

Output Section

$$\text{W-PROD}_{(1932\text{-}39)} = 6.97984\,\text{W-FERT}_t^{.03327}\,\text{W-SEED}_t^{.10712}\,\text{W-LABR}_t^{.16947}\,\text{W-MACH}_t^{.12740}\,\text{W-RE}_t^{.24783}\,\text{W-FOR}_t^{.11129}\,\text{W-MISC}_t^{.07631}\,\text{W-INT}_t^{.02159}\,\text{W-RETX}_t^{.05353}$$

$$\text{W-PROD}_{(1940\text{-}49)} = 59.12276\,\text{W-FERT}_t^{.02755}\,\text{W-SEED}_t^{.06657}\,\text{W-LABR}_t^{.11183}\,\text{W-MACH}_t^{.07586}\,\text{W-RE}_t^{.10996}\,\text{W-FOR}_t^{.09281}\,\text{W-MISC}_t^{.04091}\,\text{W-INT}_t^{.02159}\,\text{W-RETX}_t^{.01896}$$

$$\text{W-PROD}_{(1950\text{-}58)} = 22.03056\,\text{W-FERT}_t^{.04563}\,\text{W-SEED}_t^{.06706}\,\text{W-LABR}_t^{.07606}\,\text{W-MACH}_t^{.15052}\,\text{W-RE}_t^{.15638}\,\text{W-FOR}_t^{.13657}\,\text{W-MISC}_t^{.06014}\,\text{W-INT}_t^{.01996}\,\text{W-RETX}_t^{.02826}$$

$$\text{W-PROD}_{(1959\text{-}67)} = 5.51658\,\text{W-FERT}_t^{.07591}\,\text{W-SEED}_t^{.05735}\,\text{W-LABR}_t^{.06768}\,\text{W-MACH}_t^{.20694}\,\text{W-RE}_t^{.27100}\,\text{W-FOR}_t^{.16005}\,\text{W-MISC}_t^{.10491}\,\text{W-INT}_t^{.02148}\,\text{W-RETX}_t^{.04729}$$

$$\text{W-SPY}_t = \text{W-PROD}_t + \text{W-GINV}_{t-1} + \text{W-CINV}_{t-1} + \text{W-IMP}_t$$

$$\text{W-PR}_t = .4584 + \underset{(.0750)}{.1594}\,\text{W-SPPR}_t - \underset{(.0001)}{.0002}\,(\text{W-SPY}_t - \text{W-UTIL}_{t-1}) + \underset{(.1296)}{.6345}\,\text{W-PR}_{t-1}$$

2SLS $\quad d = 1.52 \quad R^2 = .681 \quad \text{MSE} = .057$

$$\text{W-FD}_t = 306.93 - \underset{(7.2488)}{16.7123}\,\text{W-PR}_t + \underset{(.0321)}{.0701}\,\text{US-PCDI}_t + \underset{(8.8431)}{21.3820}\,\text{WARDUMY} - \underset{(.8813)}{1.2875}\,\text{TIME}$$

ATS-2 $\quad \rho = \underset{(.1679)}{.3254} \quad d = 2.02 \quad R^2 = .664 \quad \text{MSE} = 106.39$

$$\text{W-CD}_t = 312.64 - \underset{(37.3846)}{49.5022}\,\text{W-PR}_t - \underset{(.5502)}{1.1914}\,\text{FG-CD}_t + \underset{(50.4523)}{219.8070}\,\text{WARDUMY} + \underset{(.1379)}{.2824}\,\text{W-CD}_{t-1}$$

2SLS $\quad d = 1.44 \quad R^2 = .730 \quad \text{MSE} = 4{,}415.7$

$$\text{W-GINV}_t = -25.038 + \underset{(40.1429)}{116.6135}\,\text{W-SPPR}_t - \underset{(74.9359)}{218.8191}\,\text{WARDUMY} + \underset{(.0602)}{.8235}\,\text{W-GINV}_{t-1}$$

LS $\quad d = 1.34 \quad R^2 = .905 \quad \text{MSE} = 21{,}377.$

$$\text{W-CINV}_t = 256.54 - \underset{(28.6043)}{86.7672}\,\text{W-PR}_t - \underset{(.0396)}{.0892}\,\text{W-GINV}_t + \underset{(.2132)}{.3917}\,\text{W-CINV}_{t-1}$$

ATS-1 $\quad d = 2.21 \quad R^2 = .748 \quad \text{MSE} = 2{,}549.8$

$$\text{W-EXP}_t = -.029 + \underset{(.0478)}{.0091}\,\text{W-INV}_{t-1} + \underset{(.0715)}{.8770}\,\text{W-EXP}_{t-1}$$

LS $\quad d = 2.29 \quad R^2 = .879 \quad \text{MSE} = 9{,}789.0$

$$\text{W-GINC}_t = 5.314 + \underset{(.0148)}{.9042}\,\text{W-PROD}_t * \text{W-PR} + \underset{(.1319)}{.9335}\,\text{W-GYPT}_t$$

ALS $\quad \rho = \underset{(.0582)}{.9715} \quad d = 2.03 \quad R^2 = .998 \quad \text{MSE} = 780.97$

[a]Coefficient standard errors are in parentheses. The estimation technique used to estimate parameters are indicated as LS (least squares), ALS (autoregressive least squares), 2SLS (two stage least square) and ATS (autoregressive two stage least squares). The first autoregressive coefficient is reported as ρ. The Durbin-Watson d statistic and equation mean square error (MSE) are also reported.

Table 5. Estimated Equations for Soybean Submodel [a]

Pre-input Section

$$\text{S-AC}_t = .4084 + \underset{(.7479)}{1.2589}\ \text{S-PR}_{t-1} - \underset{(.0363)}{.0815}\ \text{FG-PR}_{t-1} + \underset{(.0893)}{.1602}\ \text{TIME} + \underset{(.0984)}{.8672}\ \text{S-AC}_{t-1}$$

LS $\quad d = 2.19 \quad R^2 = .989 \quad MSE = 1.570$

$$\text{S-STK}_t = -1.506 + \underset{(.0476)}{1.0923}\ \text{S-PROD}_{t-1}$$

LS $\quad d = 2.18 \quad R^2 = .936 \quad MSE = 5{,}667.1$

$$\text{S-STKAVE}_t = (\text{S-STK}_{t-1} + \text{S-STK}_t)/2$$

$$\text{S-MPUR}_t = -1.902 + \underset{(.0269)}{.0658}\ \text{S-GINC}_{t-1} + \underset{(.1617)}{.6743}\ \text{S-MPUR}_{t-1}$$

LS $\quad d = 2.34 \quad R^2 = .967 \quad MSE = 229.78$

$$\text{S-MSTK}_t = 7.2425 + \underset{(.5480)}{.3417}\ \text{S-MPUR}_t + \underset{(.1036)}{1.0048}\ \text{S-MSTK}_{t-1}$$

ATS-1 $\quad d = 2.23 \quad R^2 = .988 \quad MSE = 2{,}543.3$

$$\text{S-MSTKAVE}_t = (\text{S-MSTK}_{t-1} + \text{S-MSTK}_t)/2$$

$$\text{S-PRLA}_t = 19.940 + \underset{(.0082)}{.0\_54}\ \text{S-GINC}_{t-1} + \underset{(.1076)}{.7076}\ \text{S-PRLA}_{t-1}$$

LS $\quad d = 2.32 \quad R^2 = .937 \quad MSE = 86.195$

$$\text{S-VALA}_t = .573 + \underset{(.0001)}{.8935}\ \text{S-PRLA}_t * \text{S-AC}_t$$

ALS $\quad \rho = \underset{(.0577)}{-.6658} \quad d = .980 \quad R^2 = .999 \quad MSE = .915$

$$\text{S-SPA}_t = \text{S-STKAVE}_t + \text{S-MSTKAVE}_t + \text{S-VALA}_t$$

Input Section

$$\text{S-FERT}_t = -.3164 + \underset{(.0009)}{.0040}\ \text{S-SPA}_t + \underset{(.0019)}{.0012}\ \text{S-GINC}_{t-1} + \underset{(.1268)}{.0024}\ \text{TIME} - \underset{(.0043)}{.0152}\ \text{TIME**2} + \underset{(.0853)}{.9548}\ \text{S-FERT}_{t-1}$$

LS $\quad d = 1.90 \quad R^2 = .983 \quad MSE = .870$

$$\text{S-SEED}_t = .862 + \underset{(.2830)}{3.3710}\ \text{S-AC}_t + \underset{(.0778)}{.1363}\ \text{S-SEED}_{t-1}$$

ALS $\quad \rho = \underset{(.1991)}{.2188} \quad d = 1.87 \quad R^2 = .997 \quad MSE = 5.112$

$$\text{S-LABR}_t = 10.870 + \underset{(.8731)}{6.9776}\ \text{S-AC}_t - \underset{(1.9792)}{5.6787}\ \text{TIME} + \underset{(.1139)}{.1851}\ \text{S-LABR}_{t-1}$$

ALS-2 $\quad \rho = \underset{(.0536)}{.8932} \quad d = 2.01 \quad R^2 = .991 \quad MSE = 21.550$

$$\text{S-MACH}_t = 1.639 + \underset{(.0273)}{.1523}\ \text{S-MSTKAVE}_t + \underset{(.1301)}{.3585}\ \text{S-MACH}_{t-1}$$

ATS-2 $\quad \rho = \underset{(.1518)}{-.0476} \quad d = 2.86 \quad R^2 = .997 \quad MSE = 34.510$

$$\text{S-RE}_t = -.9873 + \underset{(.0002)}{.0502}\ \text{S-VALA}_t + \underset{(.0273)}{.2593}\ \text{TIME}$$

ATS-2 $\quad \rho = \underset{(.0192)}{-.0660} \quad d = .98 \quad R^2 = .999 \quad MSE = .521$

$$\text{S-FOR}_t = 46.694 - \underset{(.1224)}{.3511}\ \text{US-MSPI}_{t-1} + \underset{(.0242)}{.1240}\ \text{S-MSTKAVE}_t + \underset{(.1487)}{.2974}\ \text{S-FOR}_{t-1}$$

2SLS $\quad d = 2.05 \quad R^2 = .995 \quad MSE = 35.296$

$$\text{S-MISC}_t = 23.533 + \underset{(.0019)}{.0045}\ \text{S-SPA}_t - \underset{(.1921)}{.2005}\ \text{US-FSPI}_{t-1} + \underset{(1.6981)}{6.4273}\ \text{TM61} + \underset{(.1551)}{.6211}\ \text{S-MISC}_{t-1}$$

2SLS $\quad d = 2.42 \quad R^2 = .994 \quad MSE = 17.510$

$$\text{S-INT}_t = -.0881 + \underset{(.0014)}{.0597}\ \text{S-STKAVE}_t$$

ATS-2 $\quad \rho = \underset{(.1275)}{-.2187} \quad d = 2.63 \quad R^2 = .975 \quad MSE = 7.7814$

$$\text{S-RETX}_t = \text{S-VALA}_t * \text{S-TXRT}_t$$

Output Section

$$\text{S-PROD}_{(1932-39)} = 5.83512\ \text{S-FERT}_t^{.00760}\ \text{S-SEED}_t^{.12419}\ \text{S-LABR}_t^{.11918}\ \text{S-MACH}_t^{.14939}\ \text{S-RE}_t^{.18878}\ \text{S-FOR}_t^{.10507}\ \text{S-MISC}_t^{.10876}\ \text{S-INT}_t^{.01631}\ \text{S-RETX}_t^{.04679}$$

$$\text{S-PROD}_{(1940-49)} = 30.84373\ \text{S-FERT}_t^{.00807}\ \text{S-SEED}_t^{.07615}\ \text{S-LABR}_t^{.07965}\ \text{S-MACH}_t^{.09074}\ \text{S-RE}_t^{.08768}\ \text{S-FOR}_t^{.08866}\ \text{S-MISC}_t^{.03608}\ \text{S-INT}_t^{.01777}\ \text{S-RETX}_t^{.01557}$$

$$\text{S-PROD}_{(1950-58)} = 13.47182\ \text{S-FERT}_t^{.01716}\ \text{S-SEED}_t^{.07046}\ \text{S-LABR}_t^{.07110}\ \text{S-MACH}_t^{.20449}\ \text{S-RE}_t^{.14599}\ \text{S-FOR}_t^{.14698}\ \text{S-MISC}_t^{.04724}\ \text{S-INT}_t^{.01987}\ \text{S-RETX}_t^{.02601}$$

$$\text{S-PROD}_{(1959-67)} = 7.49232\ \text{S-FERT}_t^{.02292}\ \text{S-SEED}_t^{.05864}\ \text{S-LABR}_t^{.07099}\ \text{S-MACH}_t^{.23030}\ \text{S-RE}_t^{.21233}\ \text{S-FOR}_t^{.14771}\ \text{S-MISC}_t^{.08874}\ \text{S-INT}_t^{.02105}\ \text{S-RETX}_t^{.03608}$$

$$\text{S-SPY}_t = \text{S-PROD}_t + \text{S-CINV}_{t-1}$$

$$\text{S-PR}_t = 1.233 + \underset{(.1333)}{.3324}\ \text{S-SPPR}_t + \underset{(.2213)}{.3858}\ \text{WARDUMY} - \underset{(.0007)}{.0015}\ (\text{S-SPY}_t - \text{S-UTIL}_{t-1}) + \underset{(.3167)}{.0280}\ \text{S-PR}_{t-1}$$

ALS $\quad \rho = \underset{(.3725)}{.2107} \quad d = 2.06 \quad R^2 = .729 \quad MSE = .088$

$$\text{S-CD}_t = -180.31 - \underset{(8.2423)}{17.6188}\ \text{S-PR}_t + \underset{(1.3638)}{2.9177}\ \text{TIME} + 2.9177\ \text{TIME} + \underset{(.5155)}{1.4579}\ \text{L-LPU}_t + \underset{(.1075)}{.6484}\ \text{S-CD}_{t-1}$$

2SLS $\quad d = 1.53 \quad R^2 = .992 \quad MSE = 340.83$

$$\text{S-CINV}_t = -7.646 + \underset{(.0188)}{.0567}\ \text{S-PROD}_t + \underset{(.2351)}{.5767}\ \text{S-CINV}_{t-1}$$

2SLS $\quad d = 1.41 \quad R^2 = .699 \quad MSE = 347.41$

$$\text{S-EXP}_t = 2.909 - \underset{(3.4258)}{4.1270}\ \text{S-PR}_t + \underset{(.2882)}{.6650}\ \text{TIME} + \underset{(.0425)}{.9986}\ \text{S-EXP}_{t-1}$$

ATS-2 $\quad \rho = \underset{(.2317)}{-.2916} \quad d = 2.40 \quad R^2 = .988 \quad MSE = 94.671$

$$\text{S-GINC}_t = -1.99 + \underset{(.0058)}{.9771}\ \text{S-PROD}_t * \text{S-PR}_t$$

ALS $\quad \rho = \underset{(.0840)}{.8718} \quad d = 2.01 \quad R^2 = .999 \quad MSE = 16.047$

[a]Coefficient standard errors are in parentheses. The estimation technique used to estimate parameters are indicated as LS (least squares), ALS (autoregressive least squares), 2SLS (two stage least square) and ATS (autoregressive two stage least squares). The first order sutoregressive coefficient is reported as ρ. The Durbin-Watson d statistic and equation mean square error (MSE) are also reported.

Table 6. Estimated Equations for Cotton Submodel[a]

Pre-input Section

$$\text{C-AC}_t = 12.276 - \underset{(1.6368)}{5.9460}\ \text{C-ACATDUMY} + \underset{(.1303)}{.0439}\ \text{C-PR}_{t-1} - \underset{(.1336)}{.4037}\ \text{TIME}$$

ALS $\rho = \underset{(.1392)}{.6175}$ $d = 1.96$ $R^2 = .865$ MSE = 9.019

$$\text{C-STK}_t = 310.37 - \underset{(15.7396)}{12.9612}\ \text{C-CD}_{t-1} + \underset{(.1750)}{.3670}\ \text{C-STK}_{t-1}$$

LS $d = 1.95$ $R^2 = .195$ MSE = 19,399.

$$\text{C-STKAVE}_t = (\text{C-STK}_{t-1} + \text{S-STK}_t)/2$$

$$\text{C-MPUR}_t = 114.489 + \underset{(15.9818)}{49.1934}\ \text{POSTWARDUMY} + \underset{(2.2515)}{4.9609}\ \text{C-EQTY}_{t-1} - \underset{(.4723)}{1.2210}\ \text{US-MHPI}_{t-1} - \underset{(.0161)}{.0175}\ \text{C-GINC}_{t-1}$$

ALS $\rho = \underset{(.2194)}{.1756}$ $d = 1.94$ $R^2 = .816$ MSE = 466.787

$$\text{C-MSTK}_t = 54.33 + \underset{(.3522)}{1.1264}\ \text{C-MPUR}_t + \underset{(.1055)}{.6437}\ \text{C-MSTK}_{t-1}$$

2SLS $d = 2.42$ $R^2 = .769$ MSE = 5,005.1

$$\text{C-MSTKAVE}_t = (\text{C-MSTK}_{t-1} + \text{C-MSTK}_t)/2$$

$$\text{C-PRLA}_t = -5.204 + \underset{(.0038)}{.0064}\ \text{C-GINC}_{t-1} + \underset{(.0429)}{.9644}\ \text{C-PRLA}_{t-1}$$

LS $d = 1.67$ $R^2 = .938$ MSE = 131.71

$$\text{C-VALA}_t = 3.339 + \underset{(.0035)}{2.0569}\ \text{C-PRLA}_t * \text{C-AC}_t$$

2SLS d = ;/97 $R^2 = .999$ MSE = 76.502

$$\text{C-SPA}_t = \text{C-STKAVE}_t + \text{C-MSTKAVE}_t + \text{C-VALA}_t$$

Input Section

$$\text{C-FERT}_t = 67.287 + \underset{(.0043)}{.0102}\ \text{C-SPA}_t - \underset{(.4435)}{1.2676}\ \text{US-FTPI}_{t-1} - \underset{(3.5284)}{4.8198}\ \text{TM61} + \underset{(.1770)}{.4706}\ \text{C-FERT}_{t-1}$$

ATS-2 $\rho = \underset{(.1639)}{.5110}$ $d = 2.29$ $R^2 = .937$ MSE = 223.37

$$\text{C-SEED}_t = .595 + \underset{(.1942)}{1.6375}\ \text{C-AC}_t - \underset{(.0340)}{.1170}\ \text{C-SDPI}_{t-1} + \underset{(.0709)}{.3475}\ \text{C-SEED}_{t-1}$$

2SLS $d = 1.88$ $R^2 = .975$ MSE = 12.310

$$\text{C-LABR}_t = 1180.8 + \underset{(9.9154)}{71.7749}\ \text{C-AC}_t - \underset{(.3127)}{.7977}\ \text{C-MSTKAVE}_t - \underset{(7.9926)}{35.6428}\ \text{TIME}$$

ATS-1 $d = 1.69$ $R^2 = .973$ MSE = 28,994.5

$$\text{C-MACH}_t = 5.5201 + \underset{(.0120)}{.2333}\ \text{C-MSTKAVE}_t - \underset{(.1429)}{.3713}\ \text{TIME}$$

2SLS $d = 2.31$ $R^2 = .929$ MSE = 74.455

$$\text{C-RE}_t = 14.656 + \underset{(.0010)}{.0498}\ \text{C-VALA}_t$$

ATS-1 $d = .562$ $R^2 = .989$ MSE = 34.292

$$\text{C-FOR}_t = 263.83 - \underset{(.9283)}{2.5507}\ \text{US-MSPI}_{t-1} + \underset{(.0735)}{.2540}\ \text{C-MSTKAVE}_t - \underset{(1.2877)}{3.2415}\ \text{TIME} + \underset{(.2019)}{.0963}\ \text{C-FOR}_{t-1}$$

ALS $\rho = \underset{(.2444)}{.2734}$ $d = 2.18$ $R^2 = .885$ MSE = 447.40

$$\text{C-MISC}_t = 259.90 - \underset{(.6683)}{2.4631}\ \text{US-FSPI}_{t-1} + \underset{(.9461)}{4.3290}\ \text{TIME} - \underset{(.0304)}{.1064}\ \text{TIME**2} + \underset{(.0024)}{.0350}\ \text{C-SPA}_t$$

ATS-1 $d = 1.63$ $R^2 = .941$ MSE = 214.15

$$\text{C-INT}_t = .03 + \underset{(.0081)}{.0629}\ \text{C-STKAVE}_t$$

2SLS $d = 2.55$ $R^2 = .705$ MSE = 25.695

$$\text{C-RETX}_t = \text{C-VALA}_t * \text{C-TXRT}_t$$

Output Section

$$\text{C-PROD}_{(1932\text{-}39)} = .00126\ \text{C-FERT}_t^{.08028}\ \text{C-SEED}_t^{.02930}\ \text{C-LABR}_t^{.59900}\ \text{C-MACH}_t^{.08157}\ \text{C-RE}_t^{.29961}\ \text{C-FOR}_t^{.10179}\ \text{C-MISC}_t^{.23047}\ \text{C-INT}_t^{.01381}\ \text{C-RETX}_t^{.05439}$$

$$\text{C-PROD}_{(1940\text{-}49)} = .04502\ \text{C-FERT}_t^{.04843}\ \text{C-SEED}_t^{.01350}\ \text{C-LABR}_t^{.43399}\ \text{C-MACH}_t^{.05491}\ \text{C-RE}_t^{.11398}\ \text{C-FOR}_t^{.09420}\ \text{C-MISC}_t^{.11886}\ \text{C-INT}_t^{.00704}\ \text{C-RETX}_t^{.01264}$$

$$\text{C-PROD}_{(1950\text{-}58)} = .10002\ \text{C-FERT}_t^{.05498}\ \text{C-SEED}_t^{.01319}\ \text{C-LABR}_t^{.30093}\ \text{C-MACH}_t^{.07483}\ \text{C-RE}_t^{.14163}\ \text{C-FOR}_t^{.09426}\ \text{C-MISC}_t^{.12674}\ \text{C-INT}_t^{.00887}\ \text{C-RETX}_t^{.01521}$$

$$\text{C-PROD}_{(1959\text{-}67)} = .06230\ \text{C-FERT}_t^{.06529}\ \text{C-SEED}_t^{.01298}\ \text{C-LABR}_t^{.22691}\ \text{C-MACH}_t^{.09111}\ \text{C-RE}_t^{.25292}\ \text{C-FOR}_t^{.10004}\ \text{C-MISC}_t^{.19043}\ \text{C-INT}_t^{.00935}\ \text{C-RETX}_t^{.02545}$$

$$\text{C-SPY}_t = \text{C-PROD}_t + \text{C-GINV}_{t-1} + \text{C-CINV}_{t-1} + \text{C-IMP}_t$$

$$\text{C-PR}_t = 3.817 + \underset{(.1151)}{.4519}\ \text{C-SPPR}_t - \underset{(.2699)}{.0126}\ (\text{C-SPY}_t - \text{C-UTIL}_{t-1}) - \underset{(.0743)}{.1598}\ \text{TIME} + \underset{(.1501)}{.5689}\ \text{C-PR}_{t-1}$$

ATS-1 $d = 2.33$ $R^2 = .753$ MSE = 13.636

$$\text{C-CD}_t = 1.037 + \underset{(.0185)}{.0125}\ \text{C-BDPI}_t + \underset{(.0636)}{.0983}\ \text{C-INV}_{t-1} + \underset{(.1408)}{.6766}\ \text{C-CD}_{t-1}$$

ALS $\rho = \underset{(.2282)}{-.0048}$ $d = 1.98$ $R^2 = .657$ MSE = .783

$$\text{C-GINV}_t = -1.631 + \underset{(.2412)}{.4690}\ \text{C-PROD}_t - \underset{(.4933)}{.8271}\ \text{C-CD}_t + \underset{(.0787)}{.1624}\ \text{C-SPPR}_t + \underset{(.1249)}{.8116}\ \text{C-GINV}_{t-1}$$

2SLS $d = 1.91$ $R^2 = .633$ MSE = 5.62

$$\text{C-CINV}_t = .0685 + \underset{(.0693)}{.3588}\ (\text{C-CINV}_{t-1} + \text{C-GINV}_{t-1}) + \underset{(.1236)}{.4239}\ \text{C-PROD}_t - \underset{(.0890)}{.4579}\ \text{C-GINV}_t - \underset{(.0325)}{.1201}\ \text{C-PR}_t + \underset{(.6283)}{1.4606}\ \text{WARDUMY}$$

2SLS $d = 1.48$ $R^2 = .795$ MSE = .912

$$\text{C-EXP}_t = .336 + \underset{(.0429)}{1.0580}\ \text{C-SPY}_t - \underset{(.0307)}{1.0972}\ \text{C-CD}_t - \underset{(.0468)}{1.0614}\ \text{C-INV}_t - \underset{(.0207)}{.0579}\ \text{C-EXP}_{t-1}$$

2SLS $d = 2.25$ $R^2 = .993$ MSE = .033

$$\text{C-GINC}_t = 112.77 + \underset{(.1329)}{5.3876}\ \text{C-PROD}_t * \text{C-PR}_t\ \underset{(.0959)}{.8068}\ \text{C-GYPT}_t$$

ATS-1 $d = .66$ $R^2 = .983$ MSE = 4,755.8

[a]Coefficient standard errors are in parentheses. The estimation technique used to estimate parameters are indicated as LS (least squares), ALS (autoregressive least squares), 2SLS (two stage least square) and ATS (autoregressive two stage least squares). The first order autoregressive coefficient is reported as ρ. The Durbin-Watson d statistic and equation mean square error (MSE) are also reported.

Table 7. Estimated Equations for Tobacco Submodel [a]

Pre-input Section

$$\text{T-AC}_t = -.0575 - \underset{(.0695)}{.1687}\ \text{T-ACATDUMY} + \underset{(.0023)}{.0155}\ \text{T-PR}_{t-1} - \underset{(.0030)}{.0064}\ \text{TIME} + \underset{(.0802)}{.7429}\ \text{T-AC}_{t-1}$$

ALS $\rho = \underset{(.1578)}{-.5419}$ $d = 1.81$ $R^2 = .815$ MSE = .0187

$$\text{T-STK}_t = 73.822 + \underset{(.0364)}{.0364}\ \text{T-PROD}_{t-1} + \underset{(21.3597)}{61.4897}\ \text{WARDUMY} - \underset{(.0491)}{.0792}\ \text{T-GINC}_{t-1} + \underset{(.1049)}{.6412}\ \text{G-STK}_{t-1}$$

ALS $\rho = \underset{(.1676)}{-.5244}$ $d = 1.84$ $R^2 = .547$ MSE = 2,360.6

$$\text{T-STKAVE}_t = (\text{T-STK}_{t-1} + \text{T-STK}_t)/2$$

$$\text{T-MPUR}_t = 9.030 + \underset{(.9848)}{2.8563}\ \text{POSTWARDUMY} + \underset{(.0011)}{.0099}\ \text{T-GINC}_{t-1} - \underset{(.0305)}{.0877}\ \text{US-MHPI}_{t-1}$$

LS $d = 2.33$ $R^2 = .802$ MSE = 2.921

$$\text{T-MSTK}_t = 7.126 + \underset{(1.0269)}{1.8531}\ \text{T-MPUR}_t + \underset{(.0843)}{.8253}\ \text{T-MSTK}_{t-1}$$

2SLS $d = 2.18$ $R^2 = .875$ MSE = 225.31

$$\text{T-MSTKAVE}_t = (\text{T-MSTK}_{t-1} + \text{T-MSTK}_t)/2$$

$$\text{T-PRLA}_t = -9.320 + \underset{(.0650)}{.1228}\ \text{T-FMSZ}_{t-1} + \underset{(.0053)}{.0094}\ \text{T-GINC}_{t-1} + \underset{(.0740)}{.9066}\ \text{T-PRLA}_{t-1}$$

LS $d = 2.27$ $R^2 = .972$ MSE = 54.593

$$\text{T-VALA}_t = .980 + \underset{(.0040)}{11.1412}\ \text{T-PRLA}_t * \text{T-AC}_t$$

ATS-1 $d = 2.13$ $R^2 = .999$ MSE = .623

$$\text{T-SPA}_t = \text{T-STKAVE}_t + \text{T-MSTKAVE}_t + \text{T-VALA}_t$$

Input Section

$$\text{T-FERT}_t = 29.058 - \underset{(.0450)}{.3651}\ \text{US-FTPI}_{t-1} + \underset{(.0038)}{.0155}\ \text{T-GINC}_{t-1} + \underset{(.0022)}{.0090}\ \text{T-SPA}_t$$

ATS-2 $\rho = \underset{(.1045)}{.3386}$ $d = 2.06$ $R^2 = .981$ MSE = 4.534

$$\text{T-LABR}_t = 2.563 + \underset{(15.6740)}{462.1345}\ \text{T-AC}_t$$

ALS $\rho = \underset{(.0500)}{.8704}$ $d = 2.28$ $R^2 = .977$ MSE = 380.88

$$\text{T-MACH}_t = \underset{(.0112)}{.300} + .0920\ \text{T-MSTKAVE}_t + \underset{(.1005)}{.1684}\ \text{T-MACH}_{t-1}$$

ATS-1 $d = 2.58$ $R^2 = .967$ MSE = .718

$$\text{T-RE}_t = 7.129 + \underset{(.0059)}{.0586}\ \text{T-VALA}_t + \underset{(1.8718)}{4.2802}\ \text{TIME** .5}$$

ATS-2 $\rho = \underset{(.0590)}{.3775}$ $d = 1.15$ $R^2 = .973$ MSE = 28.226

$$\text{T-FOR}_t = 45.644 - \underset{(.3953)}{.6898}\ \text{US-MSPI}_{t-1} + \underset{(.1084)}{.4251}\ \text{T-MSTKAVE}_t - \underset{(.5429)}{1.0043}\ \text{TIME}$$

ATS-2 $\rho = \underset{(.1462)}{.5289}$ $d = 2.01$ $R^2 = .907$ MSE = 52.699

$$\text{T-MISC}_t = 58.755 + \underset{(.0025)}{.0252}\ \text{T-SPA}_t - \underset{(.0880)}{.8938}\ \text{US-FSPI}_{t-1}$$

ATS-2 $\rho = \underset{(.0852)}{.3586}$ $d = 1.32$ $R^2 = .972$ MSE = 11.478

$$\text{T-INT}_t = -.193 + \underset{(.0036)}{.0640}\ \text{T-STKAVE}_t$$

ATS-2 $\rho = \underset{(.1335)}{-.3645}$ $d = 2.16$ $R^2 = .854$ MSE = 3.331

$$\text{T-RETX}_t = \text{T-VALA}_t * \text{T-TXRT}_t$$

Output Section

$$\text{T-PROD}_{(1932-39)} = 11.75250\ \text{T-FERT}_t^{.06041}\ \text{T-LABR}_t^{.38559}\ \text{T-MACH}_t^{.01978}\ \text{T-RE}_t^{.28661}\ \text{T-FOR}_t^{.06364}\ \text{T-MISC}_t^{.09763}\ \text{T-INT}_t^{.02981}\ \text{T-RETX}_t^{.03977}$$

$$\text{T-PROD}_{(1940-49)} = 45.63873\ \text{T-FERT}_t^{.04570}\ \text{T-LABR}_t^{.34342}\ \text{T-MACH}_t^{.01386}\ \text{T-RE}_t^{.13224}\ \text{T-FOR}_t^{.06521}\ \text{T-MISC}_t^{.05163}\ \text{T-INT}_t^{.01654}\ \text{T-RETX}_t^{.01065}$$

$$\text{T-PROD}_{(1950-58)} = 49.47014\ \text{T-FERT}_t^{.03709}\ \text{T-LABR}_t^{.32368}\ \text{T-MACH}_t^{.02045}\ \text{T-RE}_t^{.16542}\ \text{T-FOR}_t^{.06384}\ \text{T-MISC}_t^{.06375}\ \text{T-INT}_t^{.00890}\ \text{T-RETX}_t^{.01362}$$

$$\text{T-PROD}_{(1959-67)} = 48.58644\ \text{T-FERT}_t^{.03034}\ \text{T-LABR}_t^{.30764}\ \text{T-MACH}_t^{.02079}\ \text{T-RE}_t^{.20103}\ \text{T-FOR}_t^{.05518}\ \text{T-MISC}_t^{.07527}\ \text{T-INT}_t^{.01006}\ \text{T-RETX}_t^{.01599}$$

$$\text{T-SPY}_t = \text{T-PROD}_t + \text{T-CINV}_{t-1} + \text{T-IMP}_t$$

$$\text{T-PR}_t = 22.774 + \underset{(.1308)}{.3495}\ \text{T-SPPR}_t - \underset{(.0016)}{.0038}\ (\text{T-SPY}_t - \text{T-UTIL}_{t-1}) + \underset{(.2327)}{.3850}\ \text{T-PR}_{t-1}$$

ALS $\rho = \underset{(.2970)}{.1812}$ $d = 2.22$ $R^2 = .794$ MSE = 15.668

$$\text{T-CD}_t = 785.31 - \underset{(.9109)}{2.3746}\ \text{T-IMP}_t + \underset{(.1587)}{.5124}\ \text{US-PCDI}_t + \underset{(.1718)}{.1647}\ \text{T-CD}_{t-1}$$

LS $d = 1.76$ $R^2 = .474$ MSE = 11,948.

$$\text{T-CINV}_t = -1.967 - \underset{(2.6939)}{7.7633}\ \text{T-PR}_t + \underset{(.1093)}{.4339}\ \text{T-PROD}_t + \underset{(.0405)}{.8760}\ \text{T-CINV}_{t-1}$$

ATS-1 $d = 1.74$ $R^2 = .978$ MSE = 16,086.

$$\text{T-EXP}_t = 298.052 - \underset{(.0238)}{.0473}\ \text{T-FRPD}_{t-1} + \underset{(3.1350)}{8.7171}\ \text{TIME} + \underset{(.2237)}{.6039}\ \text{T-EXP}_{t-1}$$

ALS $\rho = \underset{(.2671)}{-.0890}$ $d = 2.00$ $R^2 = .527$ MSE = 5,535.1

$$\text{T-GINC}_t = 37.342 + \underset{(.0011)}{.0092}\ \text{T-PROD}_t * \text{T-PR}_t$$

ATS-2 $\rho = \underset{(.1377)}{.4601}$ $d = 1.92$ $R^2 = .902$ MSE = 7,255.4

[a] Coefficient standard errors are in parentheses. The estimation technique used to estimate parameters are indicated as LS (least squares), ALS (autoregressive least squares), 2SLS (two stage least square) and ATS (autoregressive two stage least squares). The first order autoregressive coefficient is reported as ρ. The Durbin-Watson d statistic and equation mean square error (SE) are also reported.

Table 8. Identity Equations for United States Submodel [a]

Pre-input Section

$$US\text{-}AC_t = FG\text{-}AC_t + W\text{-}AC_t + S\text{-}AC_t + C\text{-}AC_t + T\text{-}AC_t + O\text{-}AC_t$$

$$US\text{-}STK_t = L\text{-}STK_t + FG\text{-}STK_t + W\text{-}STK_t + S\text{-}STK_t + C\text{-}STK_t + T\text{-}STK_t + O\text{-}STK_t$$

$$US\text{-}STKAVE_t = L\text{-}STKAVE_t + FG\text{-}STKAVE_t + W\text{-}STKAVE_t + S\text{-}STKAVE_t + C\text{-}STKAVE_t + T\text{-}STKAVE_t + O\text{-}STKAVE_t$$

$$US\text{-}MPUR_t = L\text{-}MPUR_t + FG\text{-}MPUR_t + W\text{-}MPUR_t + S\text{-}MPUR_t + C\text{-}MPUR_t + T\text{-}MPUR_t + O\text{-}MPUR_t$$

$$US\text{-}MSTK_t = L\text{-}MSTK_t + FG\text{-}MSTK_t + W\text{-}MSTK_t + S\text{-}MSTK_t + C\text{-}MSTK_t + T\text{-}MSTK_t + O\text{-}MSTK_t$$

$$US\text{-}MSTKAVE_t = L\text{-}MSTKAVE_t + FG\text{-}MSTKAVE_t + W\text{-}MSTKAVE_t + S\text{-}MSTKAVE_t + C\text{-}MSTKAVE_t + T\text{-}MSTKAVE_t + O\text{-}MSTKAVE_t$$

$$US\text{-}VALA_t = L\text{-}VALA_t + FG\text{-}VALA_t + W\text{-}VALA_t + S\text{-}VALA_t + C\text{-}VALA_t + T\text{-}VALA_t + O\text{-}VALA_t$$

$$US\text{-}SPA_t = US\text{-}STKAVE_t + US\text{-}MSTKAVE_t + US\text{-}VALA_t$$

Input Section

$$US\text{-}FERT_t = FG\text{-}FERT_t + W\text{-}FERT_t + S\text{-}VALA_t + C\text{-}VALA_t + T\text{-}FERT_t + O\text{-}FERT_t$$

$$US\text{-}SEED_t = FG\text{-}SEED_t + W\text{-}SEED_t + S\text{-}SEED_t + C\text{-}SEED_t + O\text{-}SEED_t$$

(continued)

(Input Section continued)

$$US\text{-}LABR_t = L\text{-}LABR_t + FG\text{-}LABR_t + W\text{-}LABR_t + S\text{-}LABR_t + C\text{-}LABR_t + T\text{-}LABR_t + O\text{-}LABR_t$$

$$US\text{-}MACH_t = L\text{-}MACH_t + FG\text{-}MACH_t + W\text{-}MACH_t + S\text{-}MACH_t + C\text{-}MACH_t + T\text{-}MACH_t + O\text{-}MACH_t$$

$$US\text{-}RE_t = L\text{-}RE_t + FG\text{-}RE_t + W\text{-}RE_t + S\text{-}RE_t\ C\text{-}RE_t + T\text{-}RE_t + O\text{-}RE_t$$

$$US\text{-}FOR_t = L\text{-}FOR_t + FG\text{-}FOR_t + W\text{-}FOR_t + S\text{-}FOR_t\ C\text{-}FOR_t + T\text{-}FOR_t + O\text{-}FOR_t$$

$$US\text{-}MISC_t = L\text{-}MISC_t + FG\text{-}MISC_t + W\text{-}MISC_t + S\text{-}MISC_t + C\text{-}MISC_t + T\text{-}MISC_t + O\text{-}MISC_t$$

$$US\text{-}INT_t = L\text{-}INT_t + FG\text{-}INT_t + W\text{-}INT_t + S\text{-}INT_t + C\text{-}INT_t + T\text{-}INT_t + O\text{-}INT_t$$

$$US\text{-}RETX_t = L\text{-}RETX_t + FG\text{-}RETX_t + W\text{-}RETX_t + S\text{-}RETX_t + C\text{-}RETX_t + T\text{-}RETX_t + O\text{-}RETX_t$$

$$US\text{-}ATE_t = (US\text{-}FERT_t + US\text{-}SEED_t + US\text{-}MACH_t + US\text{-}RE_t + US\text{-}FOR_t + US\text{-}MISC_t + US\text{-}INT_t + US\text{-}RETX_t + L\text{-}LPUR_t + L\text{-}FEED_t) * US\text{-}ADJ_t$$

Output Section

$$US\text{-}GINC_t = L\text{-}GINC_t + FG\text{-}GINC_t + W\text{-}GINC_t + S\text{-}GINC_t + C\text{-}GINC_t + T\text{-}GINC_t + O\text{-}GINC_t$$

$$US\text{-}NINC_t = US\text{-}GINC_t - US\text{-}ATE_t$$

[a]Coefficient standard errors are in parentheses. The estimation technique used to estimate parameters are indicated as LS (least squares), ALS (autoregressive least squares), 2SLS (two stage least square) and ATS (autoregressive two stage least squares). The first order autoregressive coefficient is reported as ρ. The Durbin-Watson d statistic and equation mean square error are also reported.

perform on the real economic system can be conducted with a simulation model of the system. The model can be used to provide decision makers with information on the probable impact of a policy change on the real system before the change is introduced into the system itself.

Econometric simulation models are not restricted by imposed optimization rules. The agricultural sector is influenced by a wide range of continuously changing forces, so that the agricultural economy can be considered to be in a constant stage of disequilibrium. Even if optimization is the utlimate goal of participants in the agricultural sector, uncertainty and other considerations influence the path that farmers take in moving toward an equilibrium position. The "feedback" characteristic of simulation also adds realism to an agricultural policy model. A feedback loop exists when a realtionship takes as data part of the information generated in previous periods [26]. Simulation models that solve relations sequentially parallel the real economy where decisions of producers and consumers not only relate to current economic and technological environments but also are conditioned by past decisions and actions.

The ability of simulation to link related subsectors and to utilize feedback information makes the technique extremely useful in tracing primary and secondary effects of alternative public policies. For example, the primary effects of increased price supports for corn would influence not only variables in the feed grain sector but also acreage planted to soybeans and wheat. Secondary impacts might occur as increased income enabled feed grain farmers to purchase additional operating and durable inputs the following year. Four or five years might be needed for the model to work out all the indirect influences on the commodity, related commodities, and aggregate agriculture.

Previous simulation studies

During the last decade, simulation techniques have been used to study a wide range of economic problems. Simulation models of firms, industries, subeconomies, and economies have been developed.

Duesenberry *et al.* [6] and Holland and Gillespie [14] have developed simulation models of national economies, the former of the United States and the latter of India. Simulation models of farm firms have been constructed by Halter and Dean [11] and Zusman and Amiad [34]. Other firm models are reported by Cyert and March [5], Bonini [1], and Eisgruber [7]. Naylor [21] reviews additional models that have been constructed to simulate the behavior of nonagricultural firms and industries.

Crom [3] has constructed a simulation model of the livestock meat economy. He used the model to appraise the effects of alternative margin levels, foreign trade policies, and price stabilization policies on the livestock industry. Craddock [2] presented a similar model. He investigated the influence of the level of corn prices on the livestock economy. Shechter [25] attempts to analyze alternative government farm policies with a simulation model that integrates micro or firm behavior and macro or aggregate behavior in agriculture.

Simulation models of the United States agricultural economy have been developed by Lin [17] and by Tyner [31]. Both studies use simulation techniques to investigate the impact of alternative government policies on aggregate resource allocation and aggregate output and income in the agricultural sector. The model in this study extends the works of Lin and Tyner and draws upon earlier econometric studies of Heady and Tweeten [12], Helmers [13], Minden [19], and Scott [24].

The simulation mechanics of this study

The computer program written to simulate the agricultural economy in this study includes the following: (a) the equivalent of econometric equations rewritten in FORTRAN computer language, (b) instructions to read-in initial data and data not generated within the system, (c) a facility to store generated data for later use, (d) a loop that instructs the computer to make the desired number of passes through the set of equations, and (e) instructions to print out the data generated in the system.

The simulation process begins by reading into the computer the initial values of all explanatory variables not generated within the system. The computer program begins a pass through the econometric equations sequentially. The first equation of the livestock submodel is solved first using the data that was "read in" and the equation parameter estimates. The generated value is stored and the second equation in the livestock submodel is processed. The generated variable estimates are eligible for use in succeeding equations. (For example, the first livestock equation estimates the value of livestock purchases in millions of 1947-1949 dollars. This estimate is used in the second livestock equation to help explain ending-year stocks of livestock). The remaining relations in the livestock pre-input section are solved and the results stored one after the other. The livestock input equations are treated next, followed by the processing of the output section of the livestock submodel. In turn, the computer generates estimates for equations in the pre-input, input, and output sections for feed grains, wheat, soybeans, cotton, and tobacco. Finally, the United States estimates are built up from the respective commodity estimates. For example, total United States fertilizer demand is the sum of the fertilizer demand estimates for feed grains, wheat, soybeans, cotton, tobacco, and actual data on fertilizer used by all other crops. When the last United States estimate is calculated, one time-year for the agricultural economy has been described, and the computer returns to the livestock pre-input equations and starts the second year of analysis.

To begin the simulation technique for the first period, we said starting values of all explanatory variables not generated within the system must be "read in." Explanatory variables include variables which influence the agricultural sector but whose values are determined outside the sector. These variables are called exogenous. A second type of explanatory variable used in the model includes variables whose values are determined within the system but in a previous time period. These variables are called time-lagged dependent variables. In the second and succeeding periods of simulation analysis, the values for lagged dependent variables are not read in as given data. Rather, the stored dependent variable estimates that were generated by the simulator in the previous time period are retrieved and utilized appropriately. The computer makes as many cycles or "passes" through the model equations as desired. Finally, the computer is instructed to print out on paper the calculated values of the dependent variables for each year.

The feed grains submodel

To illustrate the internal workings of the simulation model, the relationships and calculations in the feed grain submodel are briefly reviewed in this section. In so doing the simulation mechanics are traced through the three groups of relationships that appear in this and the other submodels; pre-input equations, input equations, and output equations.

Pre-input equations: The purpose of the pre-input section (table 3) is to provide estimates of feed grain acreage, commodity stocks, machinery stocks, and the stock of physical assets needed in the input section to estimate input usage. Previous year simulation estimates of feed grain price, feed grain acreage, and wheat price, along with current-year actual data on acreage diversions, are used to estimate feed grain acreage in the current year. The acreage and price of land estimates determine the value of land used to produce feed grains. The simulated level of feed grain production for the previous year is utilized to estimate the farmer stock of grain. Beginning-year machinery stock and current-year machinery purchases determine the level of ending-year machinery stock. The level of machinery purchases is calculated before the stock estimate and is influenced by gross receipts generated in the last iteration, the equity ratio of the preceding year, and a variable representing the temporary expansion of machinery purchases following World War II.

Input equations: The input section generates estimates of current-year input levels to be fed later into Cobb-Douglas production functions. Determinants of resource use include predetermined variables, such as previous-year input prices, real estate tax rates, and variables that were processed in the pre-input section or were assigned values from the previous-year iteration of the simulation model. The feed grain acreage estimate (generated a few equations back in the pre-input section) appears in the seed and labor equations. The average stock of machinery estimate aids in calculating labor usage, machinery interest and depreciation expense, and fuel, oil, and repairs expenses. The value of land estimates appears in the real estate and real estate tax equations, while the stock of physical assets estimate is used in the fertilizer and miscellaneous expense relations.

Output equations: The final submodel section directly or indirectly uses all the information generated in the previous two sections. The input estimates, which are partially dependent on the simulated values for pre-input variables, are funneled into the appropriate feed grain production function. The resulting production estimate, along with carry-in and imports, determines feed grain supply. The level of supply measured against previous-year simulated commercial and export demand is used as a determinant of feed grain price. The feed grain price estimate and other variables, including the simulated level of livestock production units from the livestock submodel, determine the current-year disposition of feed grains. The final equation estimates feed grain gross income as a function of current-year production, price, and government payments. A similar simulation procedure is used for the remaining commodity submodels.

Model validation

For use in evaluating policies, predicted equations in a simulation model must be reasonably valid representations of the real system. To be valid, the structural and behavioral relationships in the model should be theoretically acceptable, and the procedures used to estimate structural coefficients should be consistent with statistical theory. Finally, the model should predict the behavior of the real system with reasonable accuracy [21, 22].

As in all econometric models, many theoretically acceptable specifications are possible for each component relation. Economic theory, a priori knowledge of the agricultural sector, and specifications used in related research were used to suggest the set of potential explanatory variables for each dependent variable. Several model formulations were tried before selecting the final model specification. Procedures used to estimate structural coefficients allow varying degrees of correlation among successive within-equation disturbances and among between-equation disturbances.

Historical verification is used to indicate the model's overall predictive ability. In the validation run (simulation 1) the estimated model is simulated with no changes in parameter estimates or exogenous data to test the model's ability to predict actual variable levels of the agricultural sector between 1932 and 1967. As a measure of correspondence between simulated and actual values, Theil coefficients [27] are calculated for each of the submodel dependent variables. The Theil coefficient is defined as:

$$u = \frac{\Sigma(A_t - P_t)^2}{\Sigma(A_t - A_{t-1})^2}$$

where the actual observation at time t is denoted by A_t and the predicted value at time t is P_t. Table 9 contains the calculated Theil coefficients for selected variables in the commodity submodels. Tables 10 through 16 present average levels for 1932-39, 1940-49, 1950-58, and 1959-67 of actual and estimated values from the validation run (denoted as SIM 1) for selected variables. Since estimated variable levels are summed across commodities, scatter diagrams were constructed for the aggregated variables to indicate the overall performance of the model (figure 2).[1] On the basis of the Theil coefficients and the scatter diagrams, it was concluded that the model reproduces historical data with sufficient accuracy to permit using the model to conduct simulation experiments.

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[1]Actual variable levels are used for non-model commodities.

Table 9. Calculated Theil-u coefficients for selected variables.[a]

Category	Live-stock	Feed grains	Wheat	Soybeans	Cotton	Tobacco
Acres	--	.85	.77	1.41	.84	.72
Livestock purchases	1.38	--	--	--	--	--
Ending calendar year commodity stocks	1.25	.81	1.12	.80	.87	.69
Machinery purchases	.83	.74	.84	1.55	.71	.82
Ending calendar year machinery stocks	1.13	.81	1.12	1.19	.81	.96
Price of land	--	.90	.83	.97	1.86	1.02
Value of land	.68	.82	.81	1.23	1.13	1.02
Stock of physical assets	.75	.88	.86	1.19	1.11	1.03
Livestock feed	1.30	--	--	--	--	--
Fertilizer and lime	--	.47	.80	3.65	1.50	.94
Seed	--	1.38	.76	1.54	.97	--
Labor	1.27	.82	.75	1.85	.73	.73
Machinery	1.14	.87	1.09	1.20	.85	.90
Real estate	.70	.75	.80	1.20	1.07	.94
Fuel, oil, repairs	1.11	1.55	.79	1.02	.78	1.06
Miscellaneous	.70	.78	.80	.69	.98	1.13
Interest on ending calendar year commodity stock	1.41	.78	1.06	.78	.80	.70
Real estate taxes	.55	.82	.96	1.21	.96	.82
Nonlabor expenses	1.08	.72	.80	1.18	.99	.97
Production	--	.68	.76	1.03	.87	.71
Livestock production units	1.41	--	--	--	--	--
Supply	--	1.79	1.29	1.33	2.25	1.42
Livestock marketings	1.28	--	--	--	--	--
Price	1.25	.78	1.17	.75	.85	.86
Commercial demand	--	1.00	.83	1.16	1.54	.80
Government inventory	--	3.41	1.30	--	1.55	--
Commercial inventory	--	.90	1.04	1.04	.89	1.30
Exports	--	2.12	1.31	.70	.79	.90
Gross income	1.19	1.10	.83	1.31	.93	.98

[a]The Theil-u coefficient is defined as the sum of squared deviations of the actual and simulated values in the current year divided by the sum of the squared deviations of current and previous year actual observations.

TABLE 10. AVERAGE LEVELS OF SELECTED LIVESTOCK VARIABLES FOR ACTUAL AND SIMULATIONS 1 THROUGH 17 1932-39, 1940-49, 1950-58, 1959-67

YEARS	ACTUAL	SIM 1	SIM 2	SIM 3	SIM 4	SIM 5	SIM 6	SIM 7	SIM 8	SIM 9	SIM 10	SIM 11	SIM 12	SIM 13	SIM 14	SIM 15	SIM 16	SIM 17
	LIVESTOCK PURCHASES (MILLION 1947-49 DOLLARS)																	
1932-39	961.9	1097.1	1020.6	1036.9	1106.0	1097.1	1106.0	1104.4	1089.8	1104.4	1089.8	1097.1	1097.1	1097.1	1097.1	1104.4	1089.8	850.3
1940-49	1485.0	1502.7	1257.5	1339.1	1480.1	1280.8	1262.5	1521.5	1480.9	1526.3	1475.9	1497.9	1507.6	1502.7	1502.7	1521.5	1480.9	989.3
1950-58	1878.3	2081.5	1648.0	1967.1	1934.6	1731.5	1632.1	2101.6	2062.2	2116.7	2044.6	2066.5	2099.1	2081.5	2081.5	2101.6	2062.2	1561.4
1959-67	2876.8	2672.8	2515.9	2572.1	2339.7	1961.1	1707.5	2692.5	2653.5	2713.8	2632.5	2651.6	2693.9	2672.8	2672.8	2692.5	2653.5	2135.8
	STOCK PHYSICAL ASSETS (MILLION 1947-49 DOLLARS)																	
1932-39	41046.2	41154.4	41057.6	41077.3	41167.7	41154.4	41167.7	41163.7	41145.1	41163.7	41145.1	41154.4	41154.4	41154.4	41154.4	41163.7	41145.1	40823.6
1940-49	44316.2	44059.4	43474.4	43729.0	44033.7	43704.7	43685.9	44102.8	44008.5	44110.0	44001.2	44051.1	44065.6	44058.4	44058.4	44102.8	44008.5	43002.9
1950-58	55529.8	55874.1	54990.2	55652.4	55645.1	55231.3	55064.4	55942.4	55801.7	55969.2	55770.6	55847.4	55905.3	55874.1	55874.1	55942.4	55801.7	54912.5
1959-67	67996.3	68463.5	67147.7	68326.9	67989.7	67378.7	67149.4	68570.7	68355.4	68605.1	68321.3	68429.4	68497.9	68463.5	68463.5	68570.7	68355.4	67635.5
	FEED EXPENSE (MILLION 1947-49 DOLLARS)																	
1932-39	1405.3	1912.9	1950.8	1900.7	1915.0	1912.9	1915.0	1909.3	1916.4	1909.3	1916.4	1912.9	1912.9	1912.9	1912.9	1909.3	1916.4	1862.4
1940-49	3175.2	3039.3	3280.0	2956.6	3037.0	2973.6	2972.5	3020.4	3061.0	3020.9	3060.5	3028.8	3039.8	3039.3	3039.3	3020.4	3061.0	2772.8
1950-58	4219.7	4483.6	4986.2	4402.3	4435.4	4301.2	4265.3	4450.2	4520.2	4453.5	4516.6	4480.4	4487.5	4483.6	4483.6	4450.2	4520.2	4182.2
1959-67	6364.2	6175.9	6603.2	6119.7	6073.4	5943.5	5886.2	6141.6	6211.0	6147.5	6204.6	6170.0	6182.3	6175.9	6175.9	6141.6	6211.0	5895.7
	LABOR REQUIREMENTS (MILLION MAN-HOURS)																	
1932-39	5923.1	6177.0	6203.4	6168.2	6178.3	6177.0	6178.3	6174.6	6179.4	6174.6	6179.4	6177.0	6177.0	6177.0	6177.0	6174.6	6179.4	6142.2
1940-49	6085.4	5949.0	6032.2	5922.6	5945.4	5913.7	5910.8	5942.6	5956.6	5942.9	5956.3	5948.6	5949.3	5949.0	5949.0	5942.6	5956.6	5867.7
1950-58	5004.8	4915.7	5016.6	4907.2	4896.7	4871.4	4858.3	4907.0	4924.6	4908.2	4923.2	4914.5	4917.1	4915.7	4915.7	4907.0	4924.6	4855.6
1959-67	3355.3	3416.3	3501.1	3409.1	3386.6	3349.1	3335.2	3409.9	3422.4	3411.5	3420.9	3414.7	3417.8	3416.3	3416.3	3409.9	3422.4	3367.7
	MACHINERY EXPENSE (MILLION 1947-49 DOLLARS)																	
1932-39	102.7	96.9	96.8	96.9	96.9	96.9	96.9	96.9	96.9	96.9	96.9	96.9	96.9	96.9	96.9	96.9	96.9	97.0
1940-49	137.3	143.8	142.9	143.9	143.7	143.7	143.7	143.8	143.7	143.8	143.7	143.8	143.8	143.8	143.8	143.8	143.7	144.2
1950-58	271.4	264.4	260.0	265.0	264.8	265.8	266.1	264.7	264.0	264.6	264.1	264.4	264.3	264.4	264.4	264.7	264.0	266.5
1959-67	285.3	295.7	285.9	296.8	297.8	300.0	301.0	296.5	295.0	296.3	295.1	295.9	295.6	295.7	295.7	296.5	295.0	301.0
	REAL ESTATE EXPENSE (MILLION 1947-49 DOLLARS)																	
1932-39	1588.9	1575.4	1575.1	1575.5	1575.4	1575.4	1575.4	1575.4	1575.3	1575.4	1575.3	1575.4	1575.4	1575.4	1575.4	1575.4	1575.3	1575.7
1940-49	1729.2	1727.0	1723.9	1727.6	1726.9	1726.9	1726.8	1727.1	1726.8	1727.1	1726.8	1727.0	1727.0	1727.0	1727.0	1727.1	1726.8	1726.5
1950-58	2240.9	2231.7	2216.6	2234.0	2233.0	2236.6	2237.4	2232.7	2230.5	2232.6	2230.6	2231.8	2231.6	2231.7	2231.7	2232.7	2230.5	2239.1
1959-67	2754.6	2788.5	2753.9	2792.4	2795.5	2803.4	2607.0	2791.1	2785.9	2790.6	2786.4	2789.0	2788.1	2788.5	2788.5	2791.1	2785.9	2807.0
	FUEL, OIL AND REPAIRS EXPENSE (MILLION 1947-49 DOLLARS)																	
1932-39	118.9	136.7	136.7	79.7	132.3	136.7	132.3	136.7	136.7	136.7	136.7	136.7	136.7	136.7	136.7	136.7	136.7	136.8
1940-49	267.0	248.2	248.1	166.7	155.7	248.2	155.7	248.2	248.2	248.2	248.2	248.2	248.2	248.2	248.2	248.2	248.2	248.3
1950-58	431.8	411.0	410.1	337.8	191.6	411.2	191.8	411.0	410.9	411.0	410.9	411.0	411.0	411.0	411.0	411.0	410.9	411.4
1959-67	472.2	487.6	485.2	419.8	211.6	488.5	212.4	487.7	487.4	487.7	487.4	487.6	487.5	487.6	487.6	487.7	487.4	488.8
	MISCELLANEOUS EXPENSE (MILLION 1947-49 DOLLARS)																	
1932-39	470.8	483.0	481.1	419.6	484.2	483.0	484.2	483.1	482.8	483.1	482.8	483.0	483.0	483.0	483.0	483.1	482.8	476.6
1940-49	554.7	548.4	536.6	471.6	548.7	541.4	541.9	549.3	547.4	549.4	547.2	548.2	548.5	548.4	548.4	549.3	547.4	527.0
1950-58	836.7	845.2	827.4	776.2	784.3	832.1	772.4	846.6	843.8	847.1	843.1	844.7	845.8	845.2	845.2	846.6	843.8	825.5
1959-67	1268.1	1268.5	1241.6	1211.4	1100.8	1246.8	1084.0	1270.6	1266.3	1271.3	1265.6	1267.8	1269.2	1268.5	1268.5	1270.6	1266.3	1251.3
	INTEREST ON STOCKS (MILLION 1947-49 DOLLARS)																	
1932-39	701.8	741.7	736.7	737.3	742.5	741.7	742.5	742.2	741.3	742.2	741.3	741.7	741.7	741.7	741.7	742.2	741.3	722.7
1940-49	806.6	789.7	761.1	770.3	788.4	769.9	768.9	792.0	787.2	792.4	786.8	789.3	790.1	789.7	789.7	792.0	787.2	728.2
1950-58	855.9	864.1	835.1	848.4	849.3	821.1	810.6	866.5	861.6	868.2	859.7	862.5	866.0	864.1	864.1	866.5	861.6	799.7
1959-67	940.1	934.4	908.1	921.4	898.0	857.8	834.9	936.9	931.9	939.4	929.3	931.9	936.9	934.4	934.4	936.9	931.9	862.3
	REAL ESTATE TAX EXPENSE (MILLION 1947-49 DOLLARS)																	
1932-39	378.7	372.6	372.6	372.7	372.6	372.6	372.6	372.6	372.6	372.6	372.6	372.6	372.6	372.6	372.6	372.6	372.6	372.7
1940-49	312.0	312.0	311.3	312.1	312.0	312.0	311.9	312.0	311.9	312.0	311.9	312.0	312.0	312.0	312.0	312.0	311.9	312.3
1950-58	416.9	418.5	414.9	419.1	418.8	419.7	419.9	418.8	418.2	418.7	418.3	418.5	418.5	418.5	418.5	418.8	418.2	420.3
1959-67	557.1	563.0	554.3	564.0	564.8	566.8	567.7	563.6	562.4	563.5	562.5	563.1	562.9	563.0	563.0	563.6	562.4	567.7
	PRODUCTION (MILLION LIVESTOCK UNITS)																	
1932-39	138.7	149.5	151.9	148.7	149.6	149.5	149.6	149.3	149.7	149.3	149.7	149.5	149.5	149.5	149.5	149.3	149.7	146.5
1940-49	173.6	164.4	170.0	162.7	164.0	161.7	161.4	163.9	164.9	164.0	164.9	164.3	164.4	164.4	164.4	163.9	164.9	159.3
1950-58	183.7	188.3	194.8	187.6	187.0	185.6	184.8	187.8	188.9	187.9	188.8	188.3	188.4	188.3	188.3	187.8	188.9	184.5
1959-67	213.2	213.2	218.5	212.7	211.2	208.3	207.4	212.8	213.6	212.9	213.5	213.1	213.3	213.2	213.2	212.8	213.6	210.5
	LIVESTOCK MARKETINGS (1947-49 = 100)																	
1932-39	70.6	78.0	79.7	77.4	78.0	78.0	78.0	77.9	78.1	77.8	78.1	78.0	78.0	78.0	78.0	77.8	78.1	75.7
1940-49	97.4	92.8	98.4	91.1	92.6	90.5	90.3	92.4	93.3	92.4	93.3	92.8	92.8	92.8	92.8	92.4	93.3	87.4
1950-58	116.6	117.3	124.2	116.4	116.1	114.2	113.4	116.7	117.9	116.8	117.8	117.2	117.4	117.3	117.3	116.7	117.9	113.1
1959-67	143.2	143.9	149.9	143.4	141.9	139.4	138.4	143.5	144.4	143.6	144.3	143.8	144.1	143.9	143.9	143.5	144.4	140.6
	PRICE (1947-49 = 100)																	
1932-39	62.7	61.0	59.2	6..6	60.9	61.0	60.9	61.2	60.8	61.2	60.8	61.0	61.0	61.0	61.0	61.2	60.8	63.4
1940-49	90.4	90.9	84.6	92.9	91.1	93.4	93.5	91.4	90.3	91.3	90.3	90.9	90.8	90.9	90.9	91.4	90.3	97.1
1950-58	79.8	75.9	68.0	77.0	77.3	79.5	80.5	76.6	75.2	76.5	75.3	76.0	75.8	75.9	75.9	76.6	75.2	80.8
1959-67	63.7	62.4	55.5	63.1	64.7	67.5	68.6	62.9	61.9	62.8	62.0	62.5	62.3	62.4	62.4	62.9	61.9	66.4
	GROSS INCOME (MILLION 1947-49 DOLLARS)																	
1932-39	7262.5	7877.9	7826.8	7890.6	7875.4	7877.9	7875.4	7881.8	7873.8	7881.8	7873.8	7877.9	7877.9	7877.	7877.9	7881.8	7873.8	7921.4
1940-49	14437.9	13769.6	13577.9	13804.8	13774.6	13807.2	13808.7	13779.9	13756.9	13779.4	13757.5	13770.1	13769.1	13769.6	13769.6	13779.9	13756.9	13843.7
1950-58	14965.6	14476.6	13735.0	14563.3	14591.7	14753.2	14623.3	14531.6	14417.8	14524.3	14426.7	14484.0	14467.9	14476.6	14476.6	14531.6	14417.8	14848.4
1959-67	15020.2	14675.6	13619.9	14771.8	14997.7	15369.6	15510.4	14750.1	14601.6	14732.6	14619.7	14693.1	14657.5	14675.6	14675.6	14750.1	14601.6	15224.0

TABLE 11. AVERAGE LEVELS OF SELECTED FEED GRAIN VARIABLES FOR ACTUAL AND SIMULATIONS 1 THROUGH 17; 1932-39, 1940-49, 1950-58, 1959-67

YEARS	ACTUAL	SIM 1	SIM 2	SIM 3	SIM 4	SIM 5	SIM 6	SIM 7	SIM 8	SIM 9	SIM 10	SIM 11	SIM 12	SIM 13	SIM 14	SIM 15	SIM 16	SIM 17
	ACRES (MILLION ACRES)																	
1932-39	139.9	149.6	141.8	147.2	149.6	149.6	149.6	150.2	148.9	150.3	148.9	149.5	149.6	149.6	149.6	150.2	148.9	100.0
1940-49	139.9	138.8	140.2	137.9	136.3	136.6	134.2	138.7	138.8	139.8	137.5	137.7	140.0	138.8	138.8	138.7	138.8	100.0
1950-58	132.3	134.9	137.9	134.3	132.2	136.5	134.0	134.7	135.4	135.9	134.0	133.7	136.4	134.9	134.9	134.7	135.4	100.0
1959-67	108.8	110.8	138.7	110.2	107.2	115.5	112.7	110.5	110.9	111.3	110.2	109.9	111.5	110.8	110.8	110.5	110.9	100.0
	STOCK PHYSICAL ASSETS (MILLION 1947-49 DOLLARS)																	
1932-39	15166.1	16072.4	13886.6	15914.2	16070.3	16072.4	16070.3	16282.4	15864.8	16295.8	15861.6	16069.0	16075.7	16072.4	16072.4	16282.4	15864.8	12069.9
1940-49	17750.4	18761.8	15811.2	18729.6	18588.8	18594.4	18339.5	19031.6	18476.5	19147.0	18353.7	18668.6	18906.4	18781.8	18781.8	19031.6	18476.5	15155.0
1950-58	23220.9	24208.6	21066.1	24153.2	23902.1	24352.1	24001.8	24480.5	23972.2	24641.2	23798.0	24050.7	24385.1	24208.6	24208.6	24480.5	23972.2	20015.6
1959-67	29836.0	28750.4	28061.6	28623.6	27913.0	28466.6	27704.5	28911.3	28584.1	29059.4	28453.4	28603.2	28882.1	28750.4	28750.4	28911.3	28584.1	26921.6
	FERTILIZER EXPENSE (MILLION 1947-49 DOLLARS)																	
1932-39	55.0	70.6	43.8	16.3	83.4	70.6	83.4	73.3	68.0	73.3	67.9	70.6	70.6	70.6	70.6	73.3	68.0	16.6
1940-49	189.9	214.9	138.6	121.6	133.4	211.1	128.8	221.3	207.3	223.1	205.5	213.2	216.8	214.9	214.9	221.3	207.3	116.4
1950-58	476.0	504.8	416.6	413.3	264.7	505.9	264.1	512.9	497.1	517.0	492.5	500.8	509.5	504.8	504.8	512.9	497.1	391.1
1959-67	1021.9	1008.6	948.4	926.8	617.5	1004.5	614.1	1014.9	1002.5	1019.4	996.2	1004.2	1013.0	1008.6	1008.6	1014.9	1002.5	908.6
	SEED EXPENSE (MILLION 1947-49 DOLLARS)																	
1932-39	157.3	176.3	163.3	172.3	176.4	176.3	176.4	177.5	175.2	177.5	175.2	176.3	176.4	176.3	176.3	177.5	175.2	90.1
1940-49	206.9	206.7	205.6	204.2	202.5	202.3	196.2	206.7	206.4	208.7	204.3	204.7	208.8	206.7	206.7	206.7	206.4	122.2
1950-58	235.9	232.2	239.5	231.0	226.3	235.1	229.7	231.7	233.3	234.4	230.1	229.5	235.4	232.2	232.2	231.7	233.3	161.0
1959-67	212.1	223.1	271.4	221.8	215.7	230.7	225.0	222.5	223.6	224.3	221.9	221.2	224.8	223.1	223.1	222.5	223.6	190.7
	LABOR REQUIREMENTS (MILLION MAN-HOURS)																	
1932-39	2797.4	2921.4	2830.3	2869.1	2921.5	2921.4	2921.5	2928.8	2913.9	2929.4	2913.3	2920.8	2922.0	2921.4	2921.4	2928.8	2913.9	2266.4
1940-49	2279.1	2212.5	2269.7	2196.1	2179.7	2178.2	2146.4	2208.0	2216.2	2222.6	2200.2	2197.9	2222.5	2212.5	2212.5	2208.0	2216.2	1693.6
1950-58	1163.0	1226.7	1319.1	1215.6	1186.0	1238.5	1204.8	1218.1	1238.3	1235.1	1218.9	1209.7	1246.1	1226.7	1226.7	1218.1	1238.3	756.9
1959-67	604.6	596.2	1039.1	586.3	542.1	648.3	611.9	588.6	602.8	599.6	592.0	585.2	606.2	596.2	596.2	588.6	602.8	445.8
	MACHINERY EXPENSE (MILLION 1947-49 DOLLARS)																	
1932-39	480.4	513.0	502.4	514.4	512.8	513.0	512.8	514.1	512.0	514.1	512.0	513.0	513.0	513.0	513.0	514.1	512.0	516.2
1940-49	605.5	640.8	604.0	644.9	641.6	646.1	646.3	643.9	637.2	643.9	637.1	640.8	640.8	640.8	640.8	643.9	637.2	649.5
1950-58	1108.6	1092.9	1042.5	1095.6	1096.9	1100.8	1102.4	1097.5	1088.2	1097.4	1088.4	1093.0	1092.8	1092.9	1092.9	1097.5	1088.2	1102.9
1959-67	959.6	981.3	910.6	983.4	987.9	990.6	991.0	985.2	977.5	984.9	977.8	981.6	980.9	981.3	981.3	985.2	977.5	989.8
	REAL ESTATE EXPENSE (MILLION 1947-49 DOLLARS)																	
1932-39	546.1	556.7	460.5	557.6	555.6	556.7	555.6	566.0	547.6	566.1	547.4	556.5	556.9	556.7	556.7	566.0	547.6	398.0
1940-49	611.8	636.0	509.6	644.2	630.1	652.4	642.8	646.8	622.7	652.1	617.1	630.9	641.7	636.0	636.0	646.8	622.7	485.6
1950-58	758.0	790.2	656.4	792.9	788.9	820.3	811.3	801.7	780.2	808.5	772.9	783.5	797.7	790.2	790.2	801.7	780.2	611.5
1959-67	1019.0	992.9	970.2	952.4	979.2	1064.2	1037.4	999.2	986.4	1005.2	981.2	987.0	998.2	992.9	992.9	999.2	986.4	924.6
	FUEL, OIL AND REPAIRS EXPENSE (MILLION 1947-49 DOLLARS)																	
1932-39	266.1	335.2	331.0	335.7	335.1	335.2	335.1	335.6	334.8	335.6	334.8	335.2	335.2	335.2	335.2	335.6	334.8	336.4
1940-49	566.8	527.2	512.7	528.9	527.6	529.3	529.4	528.5	525.8	528.5	525.8	527.2	527.3	527.2	527.2	528.5	525.8	530.7
1950-58	852.0	784.8	764.9	785.9	786.4	788.0	788.6	786.7	783.0	786.6	783.1	784.9	784.8	784.8	784.8	786.7	783.0	788.8
1959-67	772.1	781.0	753.1	781.9	783.6	784.7	784.8	782.6	779.5	782.4	779.6	781.1	780.9	781.0	781.0	782.6	779.5	784.4
	MISCELLANEOUS EXPENSE (MILLION 1947-49 DOLLARS)																	
1932-39	164.7	175.9	147.2	144.2	177.7	175.9	177.7	178.7	173.1	178.7	173.1	175.9	175.9	175.9	175.9	178.7	173.1	122.1
1940-49	199.8	211.0	168.6	179.0	209.4	208.4	205.9	214.5	206.6	216.1	205.0	209.5	212.6	211.0	211.0	214.5	206.6	159.1
1950-58	292.7	313.5	269.3	284.1	284.8	315.5	286.1	317.4	310.1	319.7	307.6	311.2	316.0	313.5	313.5	317.4	310.1	255.1
1959-67	487.3	468.1	457.1	442.2	387.2	464.1	384.2	470.4	465.8	472.5	463.9	466.0	470.0	468.1	468.1	470.4	465.8	440.0
	INTEREST ON STOCKS (MILLION 1947-49 DOLLARS)																	
1932-39	190.7	213.0	196.9	201.8	214.3	213.0	214.3	214.5	211.5	214.5	211.5	213.0	213.0	213.0	213.0	214.5	211.5	169.1
1940-49	264.8	262.1	240.1	247.8	257.1	229.2	224.9	263.6	260.1	264.4	259.3	261.3	262.9	262.1	262.1	263.6	260.1	217.8
1950-58	290.9	303.4	283.0	296.1	285.0	273.8	262.5	305.3	302.0	306.9	300.0	301.8	305.4	303.4	303.4	305.3	302.0	258.2
1959-67	384.4	360.7	362.3	353.0	323.9	253.9	239.1	362.1	359.2	364.1	357.4	358.7	362.5	360.7	360.7	362.1	359.2	328.3
	REAL ESTATE TAX EXPENSE (MILLION 1947-49 DOLLARS)																	
1932-39	128.4	133.6	111.7	133.7	133.3	133.6	133.3	135.7	131.5	135.8	131.5	133.6	133.6	133.6	133.6	135.7	131.5	92.6
1940-49	108.4	118.1	93.6	119.7	117.0	121.0	119.2	120.2	115.5	121.2	114.5	117.1	119.2	118.1	118.1	120.2	115.5	89.3
1950-58	145.6	154.3	127.5	154.8	154.0	160.2	158.4	156.6	152.3	157.9	150.8	152.9	155.8	154.3	154.3	156.6	152.3	118.4
1959-67	222.0	212.7	208.0	212.6	209.6	228.4	222.5	214.1	211.3	215.4	210.1	211.4	213.8	212.7	212.7	214.1	211.3	198.2
	PRODUCTION (MILLION TONS)																	
1932-39	78.6	83.0	74.5	77.4	83.5	83.0	83.5	83.8	82.3	83.8	82.3	83.0	83.0	83.0	83.0	83.8	82.3	61.9
1940-49	106.2	107.2	100.0	102.4	104.6	92.6	90.3	107.7	106.5	108.1	106.1	106.8	107.6	107.2	107.2	107.7	106.5	91.4
1950-58	118.7	120.1	111.5	117.2	112.3	108.4	104.0	120.8	119.5	121.4	118.7	119.4	120.8	120.1	120.1	120.8	119.5	101.4
1959-67	151.7	148.7	151.3	145.7	133.7	98.2	92.5	149.3	148.1	150.1	147.3	147.9	149.4	148.7	148.7	149.3	148.1	138.2
	PRICE (DOLLARS PER TON)																	
1932-39	37.65	37.54	22.95	42.87	37.13	37.54	37.13	38.72	36.31	38.72	36.31	37.55	37.54	37.54	37.54	38.72	36.31	56.85
1940-49	51.02	46.97	26.25	51.18	49.21	59.84	61.83	48.68	45.00	48.52	45.16	47.13	46.80	46.97	46.97	48.68	45.00	60.83
1950-58	41.25	41.68	21.10	43.68	47.04	49.70	52.75	43.36	40.00	43.04	40.37	42.00	41.31	41.68	41.68	43.36	40.00	54.22
1959-67	27.90	33.19	16.05	34.54	39.99	55.65	58.23	34.35	32.09	33.98	32.41	33.55	32.86	33.19	33.19	34.35	32.09	37.65
	GROSS INCOME (MILLION 1947-49 DOLLARS)																	
1932-39	587.9	841.6	614.5	871.7	836.7	841.6	838.7	862.2	820.4	862.3	820.4	841.5	841.6	841.6	841.6	862.2	820.4	903.5
1940-49	1466.6	1604.5	1216.0	1635.3	1623.1	1683.9	1691.7	1638.2	1565.6	1638.3	1565.5	1604.5	1604.5	1604.5	1604.5	1638.2	1565.6	1687.2
1950-58	1851.2	1979.4	1553.4	1997.7	2024.5	2041.9	2057.8	2016.8	1943.3	2015.1	1945.7	1981.2	1977.1	1979.4	1979.4	2016.8	1943.3	2065.4
1959-67	2686.8	2731.7	1842.8	2746.8	2795.2	2811.7	2798.9	2762.6	2702.2	2758.3	2706.1	2736.1	2727.8	2731.7	2731.7	2762.6	2702.2	2768.6

TABLE 12. AVERAGE LEVELS OF SELECTED WHEAT VARIABLES FOR ACTUAL AND SIMULATIONS 1 THROUGH 17; 1932-39, 1940-49, 1950-58, 1959-67

YEARS	ACTUAL	SIM 1	SIM 2	SIM 3	SIM 4	SIM 5	SIM 6	SIM 7	SIM 8	SIM 9	SIM 10	SIM 11	SIM 12	SIM 13	SIM 14	SIM 15	SIM 16	SIM 17
ACRES (MILLION ACRES)																		
1932-39	60.0	59.6	60.4	61.3	59.5	59.6	59.5	59.6	59.6	59.6	59.6	59.6	59.6	59.6	59.6	59.6	59.6	50.0
1940-49	64.4	62.4	62.0	64.1	63.6	65.9	67.0	62.8	62.0	62.4	62.4	62.8	62.0	62.4	62.4	62.8	62.0	50.0
1950-58	59.8	60.2	61.5	60.9	62.4	61.7	63.3	60.8	59.6	60.2	60.2	60.8	59.6	60.2	60.2	60.8	59.6	50.0
1959-67	52.2	51.5	60.4	52.0	54.4	54.7	56.3	51.8	51.1	51.5	51.5	51.8	51.1	51.5	51.5	51.8	51.1	50.0
STOCK PHYSICAL ASSETS (MILLION 1947-49 DOLLARS)																		
1932-39	4194.8	4543.6	4570.1	4609.5	4535.3	4543.6	4535.3	4545.8	4541.5	4543.9	4543.4	4545.5	4541.8	4543.6	4543.6	4545.8	4541.5	4017.8
1940-49	5556.9	5623.8	4908.7	5775.6	5766.0	5968.7	6076.5	5713.1	5527.5	5624.8	5622.6	5712.1	5528.8	5623.8	5623.8	5713.1	5527.5	4820.8
1950-58	6651.3	7088.4	6265.8	7185.7	7366.4	7281.1	7472.7	7227.5	6929.8	7089.9	7086.8	7226.0	6931.3	7088.4	7088.4	7227.5	6929.8	6337.1
1959-67	7892.5	7577.1	7795.3	7662.6	7987.0	8029.2	8226.2	7693.4	7470.5	7578.2	7576.0	7692.2	7471.6	7577.1	7577.1	7693.4	7470.5	7451.0
FERTILIZER EXPENSE (MILLION 1947-49 DOLLARS)																		
1932-39	19.8	15.7	15.8	2.0	19.4	15.7	19.4	15.8	15.7	15.7	15.7	15.8	15.7	15.7	15.7	15.8	15.7	11.3
1940-49	46.3	59.0	54.1	38.4	27.9	62.0	30.6	59.7	58.2	59.0	59.0	59.7	58.2	59.0	59.0	59.7	58.2	52.0
1950-58	105.8	112.2	101.8	93.3	47.5	114.4	48.9	113.6	110.6	112.3	112.2	113.6	110.6	112.2	112.2	113.6	110.6	103.2
1959-67	207.4	199.6	201.0	183.8	102.6	203.7	104.7	200.8	198.4	199.6	199.6	200.8	198.4	199.6	199.6	200.8	198.4	197.7
SEED EXPENSE (MILLION 1947-49 DOLLARS)																		
1932-39	151.6	150.5	152.3	153.9	150.3	150.5	150.3	150.6	150.5	150.6	150.5	150.6	150.5	150.5	150.5	150.6	150.5	128.5
1940-49	160.3	157.5	156.6	160.7	161.1	165.4	168.8	158.4	156.5	157.5	157.5	158.4	156.5	157.5	157.5	158.4	156.5	129.0
1950-58	149.9	153.1	156.0	154.2	159.8	156.6	162.0	154.4	151.7	153.2	153.1	154.3	151.7	153.1	153.1	154.4	151.7	129.7
1959-67	140.1	135.8	156.2	136.7	142.8	143.2	147.3	136.7	135.0	135.8	135.8	136.7	135.0	135.8	135.8	136.7	135.0	132.5
LABOR REQUIREMENTS (MILLION MAN-HOURS)																		
1932-39	485.9	476.1	481.0	485.7	475.5	476.1	475.5	476.2	476.0	476.1	476.1	476.1	476.0	476.1	476.1	476.2	476.0	412.6
1940-49	407.3	398.2	408.1	406.1	404.5	417.2	423.8	399.5	396.7	398.2	398.2	399.5	396.7	398.2	398.2	399.5	396.7	314.5
1950-58	241.6	234.4	276.7	236.9	244.4	239.8	247.8	234.7	234.0	234.4	234.4	234.7	234.0	234.4	234.4	234.7	234.0	161.7
1959-67	145.2	137.3	224.7	139.3	150.7	152.7	161.2	136.7	138.3	137.3	137.4	136.7	138.3	137.3	137.3	136.7	138.3	124.6
MACHINERY EXPENSE (MILLION 1947-49 DOLLARS)																		
1932-39	101.5	103.3	103.2	104.8	103.1	103.3	103.1	103.3	103.3	103.3	103.3	103.3	103.3	103.3	103.3	103.3	103.3	104.9
1940-49	139.6	149.7	132.3	153.5	151.5	154.3	155.0	151.4	148.0	149.8	149.7	151.4	148.0	149.7	149.7	151.4	148.0	154.2
1950-58	255.5	271.5	223.6	274.4	277.2	277.4	280.9	275.8	266.4	271.5	271.4	275.8	266.5	271.5	271.5	275.8	266.4	260.5
1959-67	246.6	244.5	202.9	246.9	252.3	252.0	255.2	249.0	240.0	244.6	244.5	249.0	240.1	244.5	244.5	249.0	240.0	249.2
REAL ESTATE EXPENSE (MILLION 1947-49 DOLLARS)																		
1932-39	182.6	193.0	194.4	200.1	192.6	193.0	192.6	193.1	192.9	193.0	193.0	193.1	192.9	193.0	193.0	193.1	192.9	167.9
1940-49	235.6	236.1	204.4	243.9	243.4	254.3	260.1	240.1	231.7	236.1	236.0	240.0	231.8	236.1	236.1	240.1	231.7	196.9
1950-58	266.2	280.5	251.5	285.2	294.6	289.9	299.9	286.3	274.0	280.6	280.4	286.2	274.0	280.5	280.5	286.3	274.0	243.8
1959-67	319.1	310.1	329.2	314.4	331.4	333.7	344.3	314.7	306.1	310.2	310.1	314.6	306.1	310.1	310.1	314.7	306.1	303.5
FUEL, OIL AND REPAIRS EXPENSE (MILLION 1947-49 DOLLARS)																		
1932-39	74.7	80.4	81.7	51.4	77.9	80.4	77.9	80.5	80.4	80.5	80.4	80.5	80.4	80.4	80.4	80.5	80.4	64.3
1940-49	175.1	170.4	160.9	146.7	115.3	178.8	123.1	172.0	168.8	170.5	170.4	172.0	168.8	170.4	170.4	172.0	168.8	150.9
1950-58	257.6	261.7	239.6	238.8	182.4	267.4	185.9	264.9	258.1	261.8	261.7	264.9	258.1	261.7	261.7	264.9	258.1	248.3
1959-67	259.1	260.7	255.1	239.5	160.3	270.1	165.2	263.7	257.8	260.7	260.7	263.6	257.8	260.7	260.7	263.7	257.8	260.5
MISCELLANEOUS EXPENSE (MILLION 1947-49 DOLLARS)																		
1932-39	57.6	65.1	65.4	51.9	65.8	65.1	65.8	65.1	65.1	65.1	65.1	65.1	65.1	65.1	65.1	65.1	65.1	57.6
1940-49	80.3	79.6	70.0	66.4	82.0	84.6	86.4	80.9	78.3	79.7	79.6	80.9	78.3	79.6	79.6	80.9	78.3	68.3
1950-58	108.6	115.2	102.2	102.4	107.0	118.1	108.7	117.3	112.9	115.2	115.2	117.2	112.9	115.2	115.2	117.3	112.9	103.6
1959-67	170.0	165.3	168.4	154.6	136.5	171.8	140.0	167.0	163.7	165.3	165.3	167.0	163.7	165.3	165.3	167.0	163.7	163.3
INTEREST ON STOCKS (MILLION 1947-49 DOLLARS)																		
1932-39	30.0	41.7	41.7	40.3	41.8	41.7	41.8	41.7	41.7	41.7	41.7	41.7	41.7	41.7	41.7	41.7	41.7	40.1
1940-49	51.7	45.5	45.3	44.2	44.7	42.9	42.1	45.6	45.4	45.5	45.5	45.6	45.4	45.5	45.5	45.6	45.4	43.6
1950-58	47.6	50.6	48.3	50.0	48.8	49.3	47.8	50.9	50.3	50.7	50.6	50.9	50.3	50.6	50.6	50.9	50.3	47.7
1959-67	53.0	51.4	51.9	50.8	48.2	48.0	46.1	51.8	51.1	51.4	51.4	51.8	51.1	51.4	51.4	51.8	51.1	50.7
REAL ESTATE TAX EXPENSE (MILLION 1947-49 DOLLARS)																		
1932-39	39.0	41.1	41.4	42.7	40.9	41.1	40.9	41.1	41.0	41.1	41.0	41.1	41.0	41.1	41.1	41.1	41.0	35.0
1940-49	41.2	42.5	36.9	44.3	44.0	46.3	47.4	43.3	41.7	42.6	42.5	43.3	41.7	42.5	42.5	43.3	41.7	35.0
1950-58	48.0	51.4	45.6	52.3	54.3	53.3	55.4	52.5	50.0	51.4	51.4	52.5	50.0	51.4	51.4	52.5	50.0	44.0
1959-67	63.4	60.4	64.5	61.3	65.0	65.5	67.8	61.4	59.5	60.4	60.4	61.3	59.5	60.4	60.4	61.4	59.5	58.9
PRODUCTION (MILLION BUSHELS)																		
1932-39	703.5	732.0	737.4	649.3	735.3	732.0	735.3	732.2	731.8	732.0	732.0	732.2	731.8	732.0	732.0	732.2	731.8	643.0
1940-49	1064.2	1073.8	1036.3	1038.4	1026.5	951.6	906.4	1079.8	1067.4	1073.8	1073.7	1079.7	1067.4	1073.8	1073.8	1079.8	1067.4	987.0
1950-58	1091.8	1117.0	1052.3	1092.2	1036.2	1066.3	1010.2	1128.4	1103.7	1117.1	1116.8	1128.3	1103.8	1117.0	1117.0	1128.4	1103.7	1032.7
1959-67	1264.1	1233.7	1260.7	1209.3	1096.3	1062.2	987.9	1248.7	1219.7	1233.9	1233.6	1248.5	1219.8	1233.7	1233.7	1248.7	1219.7	1217.2
PRICE (DOLLARS PER BUSHEL)																		
1932-39	1.37	1.09	1.03	1.34	1.08	1.09	1.08	1.09	1.08	1.09	1.09	1.09	1.08	1.09	1.09	1.09	1.08	1.35
1940-49	1.84	1.75	1.13	1.86	1.90	2.15	2.29	1.80	1.69	1.75	1.75	1.80	1.70	1.75	1.75	1.80	1.69	2.03
1950-58	1.73	1.63	1.04	1.71	1.87	1.73	1.94	1.69	1.58	1.63	1.63	1.69	1.58	1.63	1.63	1.69	1.58	1.88
1959-67	1.20	1.35	0.93	1.40	1.65	1.72	1.88	1.38	1.31	1.35	1.35	1.38	1.31	1.35	1.35	1.38	1.31	1.38
GROSS INCOME (MILLION 1947-49 DOLLARS)																		
1932-39	699.0	639.7	607.6	702.5	637.0	639.7	637.0	643.7	635.8	639.9	639.6	643.5	636.0	639.7	639.7	643.7	635.8	704.7
1940-49	1659.7	1696.2	1040.2	1745.0	1765.9	1833.3	1871.8	1753.1	1632.1	1696.9	1695.5	1752.5	1632.9	1696.2	1696.2	1753.1	1632.1	1811.7
1950-58	1685.9	1683.2	1020.8	1719.3	1784.7	1747.6	1806.4	1754.2	1605.9	1684.0	1682.4	1753.4	1606.6	1683.2	1683.2	1754.2	1605.9	1787.1
1959-67	1641.6	1772.3	1121.6	1801.0	1902.0	1921.3	1951.1	1831.2	1719.8	1772.9	1771.8	1830.6	1720.3	1772.3	1772.3	1831.2	1719.8	1792.2

TABLE 13. AVERAGE LEVELS OF SELECTED SOYBEANS VARIABLES FOR ACTUAL AND SIMULATIONS 1 THROUGH 17: 1932-39, 1940-49, 1950-58, 1959-67

YEARS	ACTUAL	SIM 1	SIM 2	SIM 3	SIM 4	SIM 5	SIM 6	SIM 7	SIM 8	SIM 9	SIM 10	SIM 11	SIM 12	SIM 13	SIM 14	SIM 15	SIM 16	SIM 17
ACRES (MILLION ACRES)																		
1932-39	2.5	2.3	5.1	2.8	2.3	2.3	2.3	2.0	2.5	2.0	2.5	2.3	2.3	2.3	2.3	2.0	2.5	1.0
1940-49	9.6	8.6	15.0	8.4	8.7	11.1	11.1	8.2	9.2	8.0	9.4	8.6	8.7	8.9	8.4	8.0	9.4	6.0
1950-58	18.4	20.5	27.1	20.0	19.6	23.6	23.2	20.0	21.0	19.7	21.3	20.3	20.6	20.9	20.0	19.5	21.4	16.6
1959-67	30.4	32.2	38.8	31.6	30.2	33.6	32.9	31.8	32.6	31.7	32.7	32.0	32.4	32.5	31.9	31.5	32.9	28.5
STOCK PHYSICAL ASSETS (MILLION 1947-49 DOLLARS)																		
1932-39	235.6	233.1	448.5	264.1	236.3	233.1	236.3	214.2	252.1	214.2	252.1	233.1	233.1	233.1	233.1	214.2	252.1	139.3
1940-49	1068.9	1094.8	1616.7	1084.6	1099.6	1309.2	1304.4	1055.9	1144.0	1024.7	1176.6	1089.5	1096.8	1129.2	1059.1	1021.1	1179.9	879.4
1950-58	3022.3	3309.8	3764.2	3279.1	3240.8	3790.1	3733.2	3274.3	3350.6	3171.3	3453.6	3289.5	3329.3	3432.7	3187.9	3152.9	3474.8	2929.6
1959-67	6308.7	6960.9	7079.0	6911.4	6748.5	7373.2	7222.1	6976.2	6942.9	6816.2	7101.1	6924.3	6993.8	7153.6	6768.9	6783.6	7135.7	6547.6
FERTILIZER EXPENSE (MILLION 1947-49 DOLLARS)																		
1932-39	0.4	0.6	2.9	1.0	0.6	0.6	0.6	0.5	0.7	0.5	0.7	0.6	0.6	0.6	0.6	0.5	0.7	0.2
1940-49	2.8	2.7	16.7	2.5	2.6	5.8	5.7	2.2	3.2	1.8	3.6	2.4	2.5	3.0	2.1	1.7	3.7	0.8
1950-58	15.2	22.7	45.6	22.1	21.9	36.7	35.7	21.4	24.4	18.5	27.3	22.1	23.0	25.9	19.4	18.1	27.7	12.8
1959-67	47.7	75.3	97.8	73.7	70.7	101.9	98.0	74.2	76.6	68.0	82.8	74.0	76.3	82.6	67.8	66.8	84.0	55.5
SEED EXPENSE (MILLION 1947-49 DOLLARS)																		
1932-39	10.7	10.0	20.8	11.9	10.2	10.0	10.2	9.1	11.0	9.1	11.0	10.0	10.0	10.0	10.0	9.1	11.0	5.2
1940-49	39.8	34.3	58.9	33.6	34.5	43.9	43.8	32.7	36.5	31.9	37.3	34.2	34.5	35.5	33.4	31.8	37.4	24.2
1950-58	70.9	80.4	106.3	78.6	77.1	92.8	91.2	78.5	82.4	77.3	83.6	79.9	81.0	82.1	78.6	76.8	84.2	65.6
1959-67	188.5	126.1	151.7	123.9	118.3	131.8	129.1	124.5	127.7	124.1	128.1	125.5	126.8	127.2	125.0	123.5	128.3	111.6
LABOR REQUIREMENTS (MILLION MAN-HOURS)																		
1932-39	27.9	32.4	55.6	36.5	32.7	32.4	32.7	30.3	34.4	30.3	34.4	32.4	32.4	32.4	32.4	30.3	34.4	21.9
1940-49	84.4	65.3	119.2	63.8	65.6	86.2	86.0	61.7	70.0	59.9	71.8	65.1	65.6	67.3	63.3	59.7	72.0	43.2
1950-58	99.2	116.6	173.5	112.6	109.5	143.7	140.3	112.5	121.1	109.8	123.7	115.6	117.8	120.5	112.8	108.7	124.9	84.3
1959-67	148.7	159.6	215.8	154.6	142.4	172.2	166.4	156.2	162.9	155.2	163.9	158.2	161.0	162.0	157.2	153.8	165.4	127.6
MACHINERY EXPENSE (MILLION 1947-49 DOLLARS)																		
1932-39	7.8	11.8	12.1	11.9	11.8	11.8	11.8	11.8	11.8	11.8	11.8	11.8	11.8	11.8	11.8	11.8	11.8	11.9
1940-49	37.9	42.0	44.5	43.4	42.2	43.1	43.0	41.6	42.4	41.2	42.8	41.9	41.9	42.3	41.5	41.2	42.8	44.0
1950-58	138.9	129.7	120.9	133.1	132.0	139.0	139.2	130.0	129.3	126.7	132.6	129.2	129.5	132.9	126.1	126.6	132.7	137.1
1959-67	247.1	281.7	245.8	286.8	288.8	308.0	308.1	284.5	278.7	276.0	287.2	280.8	281.7	290.3	272.6	275.5	287.6	296.9
REAL ESTATE EXPENSE (MILLION 1947-49 DOLLARS)																		
1932-39	9.1	8.5	18.6	10.3	8.7	8.5	8.7	7.7	9.4	7.7	9.4	8.5	8.5	8.5	8.5	7.7	9.4	4.3
1940-49	40.8	40.9	64.5	40.5	41.3	53.5	53.4	39.3	43.1	37.9	44.6	40.8	41.1	42.5	39.4	37.7	44.8	30.7
1950-58	108.9	123.6	146.8	121.6	120.3	149.9	147.6	121.9	125.6	117.9	129.6	122.8	124.6	128.6	118.8	117.1	130.6	104.1
1959-67	233.5	256.6	270.0	253.3	245.9	283.4	276.8	256.7	256.4	251.5	261.6	255.1	258.1	263.4	249.9	250.0	263.1	234.4
FUEL, OIL AND REPAIRS EXPENSE (MILLION 1947-49 DOLLARS)																		
1932-39	4.8	6.8	7.0	2.4	6.4	6.8	6.4	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.9
1940-49	38.5	39.8	41.7	35.2	29.3	40.7	29.9	39.5	40.1	39.2	40.4	39.7	39.7	40.1	39.4	39.2	40.4	41.3
1950-58	114.2	111.8	105.1	109.4	96.7	118.9	102.2	112.1	111.5	109.6	114.0	111.5	111.7	114.3	109.1	109.5	114.1	117.4
1959-67	207.4	230.0	202.9	229.2	214.1	249.7	228.7	232.1	227.8	225.7	234.1	229.3	230.0	236.5	223.2	225.4	234.4	241.4
MISCELLANEOUS EXPENSE (MILLION 1947-49 DOLLARS)																		
1932-39	6.4	6.9	8.7	2.6	7.3	6.9	7.3	6.8	7.1	6.8	7.1	6.9	6.9	6.9	6.9	6.8	7.1	6.1
1940-49	17.6	15.2	21.1	9.4	15.7	17.2	17.6	14.7	15.7	14.5	16.0	15.1	15.2	15.5	14.9	14.4	16.0	12.9
1950-58	37.8	43.2	48.7	37.6	38.8	48.3	43.9	42.8	43.8	41.7	44.9	43.0	43.4	44.5	42.0	41.5	45.1	39.2
1959-67	119.2	126.8	129.3	121.8	112.9	132.6	119.3	126.8	126.8	125.1	128.5	126.4	127.2	129.0	124.7	124.7	128.9	121.5
INTEREST ON STOCKS (MILLION 1947-49 DOLLARS)																		
1932-39	1.6	2.0	2.7	1.7	2.0	2.0	2.0	1.9	2.1	1.9	2.1	2.0	2.0	2.0	2.0	1.9	2.1	1.4
1940-49	9.6	9.6	12.0	9.1	9.3	7.2	7.0	9.3	9.8	9.2	9.9	9.5	9.5	9.6	9.4	9.2	9.9	8.3
1950-58	23.0	23.4	25.6	23.1	22.6	18.3	17.7	23.2	23.7	22.8	24.1	23.3	23.5	24.0	22.9	22.7	24.2	21.9
1959-67	43.3	46.7	47.3	46.3	44.8	32.4	31.3	46.7	46.6	45.7	47.6	46.4	46.8	47.8	45.5	45.5	47.8	44.4
REAL ESTATE TAX EXPENSE (MILLION 1947-49 DOLLARS)																		
1932-39	2.1	2.0	4.3	2.4	2.0	2.0	2.0	1.8	2.2	1.8	2.2	2.0	2.0	2.0	2.0	1.8	2.2	0.9
1940-49	7.1	7.0	11.6	6.9	7.1	9.3	9.3	6.7	7.4	6.5	7.7	7.0	7.1	7.3	6.7	6.4	7.7	5.1
1950-58	20.1	23.2	27.7	22.8	22.5	28.3	27.9	22.8	23.6	22.1	24.3	23.0	23.4	24.2	22.2	21.9	24.5	19.3
1959-67	45.6	50.2	52.9	49.6	48.1	55.7	54.3	50.2	50.2	49.2	51.2	49.9	50.5	51.6	48.9	48.9	51.5	45.7
PRODUCTION (MILLION BUSHELS)																		
1932-39	41.6	39.4	58.0	34.3	39.5	39.3	39.5	37.2	41.4	37.2	41.4	39.3	39.3	39.3	39.3	37.2	41.4	28.0
1940-49	179.9	176.1	213.0	169.3	171.8	135.5	131.4	172.4	179.8	170.5	181.5	175.1	175.6	177.5	173.7	170.3	181.7	157.4
1950-58	391.2	407.3	439.1	402.3	392.6	314.9	303.9	404.2	410.7	395.6	419.0	405.6	408.3	416.7	397.3	394.3	420.3	381.6
1959-67	731.9	801.5	804.6	795.6	769.6	539.7	521.4	802.5	800.4	786.0	816.7	798.1	804.1	820.6	782.0	783.0	819.6	771.3
PRICE (DOLLARS PER BUSHEL)																		
1932-39	1.56	1.60	1.58	2.02	1.58	1.60	1.58	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	2.50
1940-49	2.52	2.50	1.52	2.71	2.62	3.74	3.85	2.57	2.43	2.51	2.49	2.50	2.50	2.56	2.44	2.51	2.49	3.06
1950-58	2.02	2.17	1.60	2.22	2.32	3.16	3.28	2.22	2.11	2.19	2.15	2.17	2.17	2.21	2.13	2.18	2.15	2.44
1959-67	1.73	1.84	1.45	1.87	1.99	3.02	3.11	1.88	1.80	1.86	1.82	1.85	1.84	1.85	1.83	1.87	1.82	2.00
GROSS INCOME (MILLION 1947-49 DOLLARS)																		
1932-39	50.6	53.1	81.5	58.9	52.7	53.2	52.7	49.8	56.2	49.8	56.2	53.1	53.1	53.1	53.1	49.8	56.2	59.0
1940-49	425.9	420.3	366.6	435.0	430.5	462.7	465.0	423.1	417.2	407.6	432.7	417.9	419.1	435.1	403.7	407.1	433.2	454.8
1950-58	720.8	842.8	670.9	853.0	871.5	948.7	949.6	858.3	827.4	824.2	861.0	840.1	844.4	878.6	806.9	822.1	863.1	890.0
1959-67	1232.9	1416.4	1113.8	1426.9	1469.0	1576.3	1565.3	1447.7	1385.1	1405.2	1426.6	1414.0	1418.2	1460.4	1372.5	1403.1	1428.6	1466.1

TABLE 14. AVERAGE LEVELS OF SELECTED COTTON VARIABLES FOR ACTUAL AND SIMULATIONS 1 THROUGH 8;, 1932-39, 1940-49, 1950-58, 1959-67

YEARS	ACTUAL	SIM 1	SIM 2	SIM 3	SIM 4	SIM 5	SIM 6	SIM 7	SIM 8
	ACRES (MILLION ACRES)								
1932-39	30.9	30.2	31.3	30.4	30.2	30.2	30.2	30.2	30.1
1940-49	22.4	24.7	26.2	24.9	24.9	25.1	25.3	24.8	24.6
1950-58	20.6	19.3	22.4	19.4	19.6	20.1	20.3	19.4	19.2
1959-67	14.3	13.4	18.7	13.5	14.0	14.7	15.1	13.5	13.3
	STOCK PHYSICAL ASSETS (MILLION 1947-49 DOLLARS)								
1932-39	5717.6	5508.7	5042.2	5727.0	5500.3	5508.7	5500.3	5600.8	5419.2
1940-49	4581.4	5579.5	4540.8	5775.2	5795.5	5957.9	6111.3	5778.0	5386.4
1950-58	5882.0	6613.1	6264.3	6704.4	6926.4	7306.9	7455.6	6834.5	6398.5
1959-67	6128.9	5029.7	6160.3	5089.3	5488.0	5733.5	5750.2	5163.5	4900.5
	FERTILIZER EXPENSE (MILLION 1947-49 DOLLARS)								
1932-39	59.3	51.6	42.8	31.9	52.6	51.6	52.6	53.1	50.1
1940-49	72.9	93.4	76.8	71.0	56.5	100.0	62.0	96.8	90.0
1950-58	138.6	156.5	145.3	135.8	83.6	168.8	93.2	160.8	152.2
1959-67	180.9	143.6	164.1	126.2	36.6	157.1	42.1	146.3	141.1
	SEED EXPENSE (MILLION 1947-49 DOLLARS)								
1932-39	70.9	68.7	70.7	68.2	69.1	68.7	69.1	68.8	68.6
1940-49	41.1	48.2	52.9	47.4	53.1	49.2	54.0	48.5	48.0
1950-58	36.4	35.7	42.6	34.5	41.4	37.6	43.2	36.1	35.4
1959-67	27.6	23.1	36.5	22.2	26.4	26.3	29.2	23.3	22.8
	LABOR REQUIREMENTS (MILLION MAN-HOURS)								
1932-39	2857.6	2854.6	2952.9	2889.2	2856.9	2854.6	2856.9	2855.4	2853.8
1940-49	1972.5	2064.2	2222.9	2103.4	2101.8	2081.3	2121.1	2064.8	2063.5
1950-58	1276.3	1206.1	1499.3	1241.8	1231.6	1240.7	1270.9	1203.9	1207.9
1959-67	605.2	602.4	1028.5	642.6	615.0	677.2	695.9	601.3	603.2
	MACHINERY EXPENSE (MILLION 1947-49 DOLLARS)								
1932-39	76.9	78.7	73.7	73.3	78.0	78.7	78.0	79.4	78.1
1940-49	89.6	97.7	84.3	91.0	91.2	100.9	93.7	99.7	95.8
1950-58	135.9	133.0	112.4	124.9	131.8	139.1	135.9	136.2	129.9
1959-67	100.5	88.4	76.6	79.1	97.6	94.3	96.8	91.0	85.9
	REAL ESTATE EXPENSE (MILLION 1947-49 DOLLARS)								
1932-39	263.3	253.3	231.0	265.1	253.0	253.3	253.0	257.8	248.9
1940-49	213.5	255.5	206.8	266.1	267.5	273.2	282.2	265.1	246.2
1950-58	264.7	300.7	287.0	306.8	315.9	333.0	340.7	311.4	290.4
1959-67	277.5	229.4	288.0	234.1	249.3	261.2	261.2	235.8	223.2
	FUEL, OIL AND REPAIRS EXPENSE (MILLION 1947-49 DOLLARS)								
1932-39	77.7	89.8	84.0	47.9	86.7	89.8	86.7	90.6	89.1
1940-49	156.4	147.0	131.0	107.2	76.0	150.7	78.9	149.4	144.7
1950-58	190.2	193.0	168.1	154.8	96.1	200.4	101.0	196.9	189.3
1959-67	148.0	136.5	122.2	99.4	26.7	143.6	27.3	139.6	133.5
	MISCELLANEOUS EXPENSE (MILLION 1947-49 DOLLARS)								
1932-39	214.3	209.3	192.9	190.2	210.7	209.3	210.7	212.5	206.1
1940-49	201.6	231.3	194.9	211.7	238.6	244.6	249.7	238.3	224.5
1950-58	256.7	289.4	277.2	268.3	278.6	313.7	297.1	297.2	281.9
1959-67	297.7	255.0	294.6	236.6	210.7	279.7	219.9	259.7	250.5
	INTEREST ON STOCKS (MILLION 1947-49 DOLLARS)								
1932-39	26.3	25.0	25.1	25.3	25.0	25.0	25.0	24.9	25.0
1940-49	15.4	20.6	20.4	21.3	20.9	21.3	21.5	20.4	20.7
1950-58	20.3	18.1	19.1	18.4	19.0	19.4	19.9	17.8	18.5
1959-67	20.9	19.6	20.0	20.0	20.9	22.1	22.5	19.3	20.0
	REAL ESTATE TAX EXPENSE (MILLION 1947-49 DOLLARS)								
1932-39	52.2	50.5	45.9	52.8	50.4	50.5	50.4	51.3	49.6
1940-49	25.3	30.5	25.0	32.0	32.0	32.8	33.9	31.7	29.4
1950-58	29.0	33.6	32.1	34.3	35.4	37.3	38.2	34.8	32.4
1959-67	31.8	25.7	32.7	26.2	28.0	29.5	29.5	26.4	24.9
	PRODUCTION (MILLION BALES)								
1932-39	12.7	12.1	11.4	10.8	12.1	12.1	12.1	12.3	11.9
1940-49	12.0	12.9	12.4	12.2	12.1	11.5	10.6	13.1	12.7
1950-58	13.4	13.7	14.1	13.3	12.6	10.5	9.5	13.9	13.6
1959-67	13.4	11.9	14.7	11.4	9.1	6.1	4.4	12.1	11.7
	PRICE (CENTS PER POUND)								
1932-39	18.07	18.43	8.86	24.56	18.46	18.43	18.46	19.56	17.29
1940-49	28.69	27.98	8.62	32.42	33.44	37.25	42.69	30.43	25.53
1950-58	29.45	27.58	8.62	30.14	34.73	47.29	53.47	30.33	24.83
1959-67	20.69	20.93	8.61	23.63	36.32	51.95	60.84	23.35	18.51
	GROSS INCOME (MILLION 1947-49 DOLLARS)								
1932-39	1300.5	1289.0	658.7	1501.4	1287.4	1289.0	1287.4	1378.1	1202.4
1940-49	1987.3	2074.4	666.5	2252.0	2306.9	2398.2	2560.7	2274.2	1879.0
1950-58	2232.3	2169.3	768.0	2289.6	2469.7	2752.6	2806.8	2404.6	1939.7
1959-67	1770.3	1579.4	792.2	1688.3	1966.3	1926.5	1659.9	1761.0	1403.5

TABLE 15. AVERAGE LEVELS OF SELECTED TOBACCO VARIABLES FOR ACTUAL AND SIMULATIONS 1 THROUGH 8;, 1932-39, 1940-49, 1950-58, 1959-67

YEARS	ACTUAL	SIM 1	SIM 2	SIM 3	SIM 4	SIM 5	SIM 6	SIM 7	SIM 8
	ACRES (MILLION ACRES)								
1932-39	1.6	1.5	1.5	1.6	1.5	1.5	1.5	1.5	1.5
1940-49	1.6	1.7	1.4	1.8	1.7	1.7	1.7	1.7	1.6
1950-58	1.5	1.6	1.1	1.7	1.7	1.6	1.7	1.7	1.5
1959-67	1.1	1.1	0.7	1.1	1.2	1.2	1.3	1.1	1.0
	STOCK PHYSICAL ASSETS (MILLION 1947-49 DOLLARS)								
1932-39	1677.5	1597.2	1597.2	1599.9	1593.2	1597.2	1593.2	1597.2	1597.2
1940-49	1855.2	1990.2	1307.2	2112.8	1980.5	2042.7	2032.7	2129.9	1859.2
1950-58	2293.3	2510.2	1245.0	2608.3	2657.7	2465.6	2614.8	2716.9	2314.2
1959-67	2428.5	2421.5	1388.2	2493.8	2659.8	2741.1	2985.4	2580.4	2267.1
	FERTILIZER EXPENSE (MILLION 1947-49 DOLLARS)								
1932-39	16.6	16.8	16.8	12.1	17.0	16.8	17.0	16.8	16.8
1940-49	33.3	34.1	23.1	31.4	26.6	34.8	27.3	36.0	32.3
1950-58	45.3	47.8	28.0	45.5	36.6	46.8	35.7	50.6	45.1
1959-67	51.7	50.9	34.7	48.8	34.5	54.0	37.6	53.0	48.8
	LABOR REQUIREMENTS (MILLION MAN-HOURS)								
1932-39	632.1	601.9	601.9	618.8	600.9	601.9	600.9	601.9	601.9
1940-49	727.8	751.6	637.9	800.1	762.7	759.6	771.1	780.5	722.8
1950-58	703.6	756.8	511.0	785.5	802.3	761.0	807.4	793.4	720.0
1959-67	536.8	504.6	335.9	522.0	555.3	574.5	627.3	529.6	479.5
	MACHINERY EXPENSE (MILLION 1947-49 DOLLARS)								
1932-39	6.6	7.1	7.1	6.5	7.0	7.1	7.0	7.1	7.1
1940-49	11.1	11.2	9.5	10.2	10.5	11.2	10.5	11.4	10.9
1950-58	17.2	16.6	11.2	15.7	15.7	16.5	15.6	17.2	15.9
1959-67	15.3	14.5	9.1	13.5	14.9	14.5	14.8	15.1	14.0
	REAL ESTATE EXPENSE (MILLION 1947-49 DOLLARS)								
1932-39	101.4	98.9	98.9	99.6	98.7	98.9	98.7	98.9	98.9
1940-49	120.1	125.9	84.6	134.0	125.8	129.1	129.0	134.2	118.1
1950-58	154.7	163.2	88.4	169.6	172.7	160.7	170.3	175.3	151.7
1959-67	157.6	162.2	101.9	167.1	176.4	181.6	196.2	171.4	153.3
	FUEL, OIL AND REPAIRS EXPENSE (MILLION 1947-49 DOLLARS)								
1932-39	18.3	22.4	22.4	12.0	21.6	22.4	21.6	22.4	22.4
1940-49	53.1	46.2	39.5	34.8	27.7	46.2	27.7	47.1	45.3
1950-58	62.6	64.5	43.6	54.2	38.1	64.0	37.7	67.0	62.0
1959-67	57.7	53.7	32.9	43.3	25.4	53.5	25.1	55.9	51.5
	MISCELLANEOUS EXPENSE (MILLION 1947-49 DOLLARS)								
1932-39	34.4	34.6	34.6	25.7	34.7	34.6	34.7	34.6	34.6
1940-49	42.6	45.7	28.5	39.1	45.3	47.0	46.6	49.2	42.4
1950-58	62.5	66.6	34.7	60.2	62.4	65.4	61.3	71.8	61.6
1959-67	79.6	78.3	52.3	72.7	62.4	86.4	70.6	82.3	74.4
	INTEREST ON STOCKS (MILLION 1947-49 DOLLARS)								
1932-39	15.6	14.3	14.3	14.1	14.3	14.3	14.3	14.3	14.3
1940-49	14.0	14.1	16.6	13.7	14.0	14.0	14.0	13.9	14.4
1950-58	9.2	8.6	12.5	8.4	8.2	8.6	8.1	8.3	9.0
1959-67	8.8	9.2	12.1	9.0	8.7	8.4	7.9	9.0	9.3
	REAL ESTATE TAX EXPENSE (MILLION 1947-49 DOLLARS)								
1932-39	14.8	14.3	14.3	14.4	14.2	14.3	14.2	14.3	14.3
1940-49	10.6	11.6	7.1	12.6	11.6	11.9	11.9	12.5	10.8
1950-58	12.9	14.4	6.1	15.1	15.4	14.1	15.1	15.7	13.1
1959-67	13.6	13.6	7.1	14.1	15.1	15.7	17.2	14.6	12.6
	PRODUCTION (MILLION POUNDS)								
1932-39	1346.8	1317.5	1317.5	1216.2	1315.0	1317.5	1315.0	1317.5	1317.5
1940-49	1685.0	1703.8	1444.8	1695.0	1638.3	1755.2	1682.5	1753.9	1654.1
1950-58	2076.9	2160.2	1546.7	2156.5	2118.2	2008.9	1976.3	2244.4	2076.3
1959-67	2044.7	2011.9	1482.1	2005.0	1967.7	1918.6	1859.0	2083.4	1940.2
	PRICE (CENTS PER POUND)								
1932-39	32.49	30.34	30.34	31.71	30.31	30.34	30.31	30.34	30.34
1940-49	48.34	51.16	31.29	52.82	52.03	51.16	52.10	52.80	49.51
1950-58	45.84	46.88	28.61	47.64	48.75	48.09	49.91	47.93	45.82
1959-67	44.54	43.05	26.66	43.58	44.91	46.13	48.20	43.88	42.23
	GROSS INCOME (MILLION 1947-49 DOLLARS)								
1932-39	427.7	438.9	438.9	425.9	437.7	438.9	437.7	438.9	438.9
1940-49	850.3	880.0	486.7	902.0	862.4	904.8	886.0	931.4	830.4
1950-58	958.7	1006.2	477.9	1019.9	1024.3	961.6	980.4	1064.9	949.1
1959-67	905.6	869.3	433.8	876.3	885.4	886.6	896.6	913.6	825.9

TABLE 16. AVERAGE LEVELS OF SELECTED U.S. VARIABLES FOR ACTUAL AND SIMULATIONS 1 THROUGH 17; 1932-39, 1940-49, 1950-58, 1959-67

YEARS	ACTUAL	SIM 1	SIM 2	SIM 3	SIM 4	SIM 5	SIM 6	SIM 7	SIM 8	SIM 9	SIM 10	SIM 11	SIM 12	SIM 13	SIM 14	SIM 15	SIM 16	SIM 17
									ACRES (MILLION ACRES)									
1932-39	375.4	383.7	380.6	383.7	383.6	383.7	383.6	384.1	383.2	384.1	383.2	383.7	383.7	383.7	383.7	384.1	383.3	323.2
1940-49	374.0	372.2	380.9	373.1	371.2	376.4	375.3	372.3	372.2	372.6	371.8	371.5	373.1	372.5	372.0	371.9	372.6	318.4
1950-58	373.1	377.4	390.9	377.2	376.4	384.4	383.6	377.4	377.6	377.6	377.3	376.6	378.4	377.9	377.0	376.8	378.3	328.5
1959-67	340.7	342.6	391.1	342.2	340.7	353.4	352.1	342.5	342.7	342.7	342.6	342.1	343.2	342.9	342.4	342.1	343.2	326.8
									STOCK PHYSICAL ASSETS (MILLION 1947-49 DOLLARS)									
1932-39	83755.	84837.	82282.	84947.	84832.	84837.	84832.	85136.	84544.	85045.	84632.	84836.	84839.	84837.	84837.	85044.	84633.	79770.
1940-49	91457.	93611.	88147.	93693.	93729.	93998.	93954.	94293.	92885.	93960.	93204.	93572.	93651.	93645.	93575.	93920.	93244.	87911.
1950-58	116291.	119554.	113534.	119537.	119661.	120362.	120267.	120426.	118716.	119946.	119181.	119485.	119626.	119677.	119431.	119876.	119251.	113247.
1959-67	144282.	143063.	141568.	142969.	142607.	143356.	142663.	143755.	142380.	143373.	142762.	142959.	143157.	143256.	142870.	143269.	142857.	139941.
									FERTILIZER EXPENSE (MILLION 1947-49 DOLLARS)									
1932-39	272.0	277.1	243.9	185.3	295.0	277.1	295.0	281.3	273.1	279.7	274.6	277.1	277.1	277.1	277.1	279.7	274.6	218.3
1940-49	623.5	682.3	587.5	543.0	525.3	691.8	532.6	694.2	669.2	689.5	673.8	681.0	683.2	682.6	681.7	688.4	674.9	574.9
1950-58	1250.8	1315.1	1208.5	1161.1	925.5	1343.7	948.7	1330.4	1300.5	1323.1	1307.3	1311.8	1318.4	1318.2	1311.8	1320.0	1310.7	1182.5
1959-67	2292.5	2260.9	2228.9	2142.2	1644.8	2303.9	1679.3	2272.0	2250.2	2264.4	2257.9	2256.3	2265.1	2268.2	2253.4	2259.9	2262.3	2139.2
									SEED EXPENSE (MILLION 1947-49 DOLLARS)									
1932-39	309.8	324.9	326.4	325.7	325.3	324.9	325.3	325.2	324.6	325.1	324.6	324.8	324.9	324.9	324.9	325.1	324.6	211.8
1940-49	523.9	522.6	549.9	521.8	526.9	536.6	540.7	522.1	523.2	522.2	523.1	521.4	523.9	523.5	521.7	521.0	524.4	399.6
1950-58	571.1	581.1	624.1	577.9	584.3	601.6	605.7	580.3	582.5	580.2	582.2	579.2	583.5	582.9	579.4	578.2	584.6	471.7
1959-67	615.7	625.5	733.3	622.0	620.6	649.3	647.9	624.5	626.5	624.7	626.3	623.9	627.1	626.6	624.4	623.1	627.9	575.3
									LABOR REQUIREMENTS (MILLION MAN-HOURS)									
1932-39	21279.0	21618.3	21680.1	21642.4	21620.9	21618.3	21620.9	21622.1	21614.4	21621.9	21614.7	21617.8	21618.9	21618.3	21618.3	21621.3	21615.3	20854.7
1940-49	18871.0	18755.2	19004.5	18806.5	18774.2	18750.7	18773.7	18771.5	18740.2	18753.9	18756.7	18741.5	18770.4	18757.3	18753.3	18740.1	18771.8	18049.3
1950-58	13175.8	13145.4	13485.3	13184.8	13155.6	13184.3	13218.7	13158.8	13135.0	13139.4	13152.2	13126.5	13167.0	13149.2	13141.5	13120.5	13173.8	12510.4
1959-67	8725.7	8746.2	9675.0	8782.9	8721.9	8904.0	8927.7	8752.1	8739.0	8740.5	8751.9	8731.6	8760.2	8748.7	8743.8	8725.8	8765.7	8502.6
									MACHINERY EXPENSE (MILLION 1947-49 DOLLARS)									
1932-39	1034.8	1069.8	1054.2	1066.6	1068.6	1069.8	1068.6	1071.5	1068.1	1070.8	1068.8	1069.8	1069.8	1069.8	1069.8	1070.8	1068.7	1074.6
1940-49	1359.0	1423.0	1355.3	1424.7	1418.5	1437.1	1430.0	1429.6	1415.8	1425.4	1420.0	1424.6	1421.2	1423.4	1422.6	1427.0	1418.4	1438.6
1950-58	2638.0	2621.4	2484.0	2622.2	2631.7	2652.1	2653.5	2634.9	2607.2	2623.2	2619.5	2625.4	2616.1	2624.7	2617.9	2627.5	2614.4	2650.0
1959-67	2692.5	2744.2	2569.0	2744.7	2777.3	2797.4	2805.1	2759.4	2729.2	2742.8	2745.7	2748.3	2739.4	2752.9	2735.2	2747.2	2741.2	2778.0
									REAL ESTATE EXPENSE (MILLION 1947-49 DOLLARS)									
1932-39	3374.8	3369.1	3261.7	3391.4	3367.2	3369.1	3367.2	3382.1	3356.4	3377.7	3360.6	3369.0	3369.2	3369.1	3369.1	3377.7	3360.7	3171.3
1940-49	3665.4	3755.8	3508.2	3770.7	3749.4	3803.7	3808.7	3767.1	3703.2	3749.1	3720.4	3734.5	3737.4	3737.4	3734.2	3747.6	3721.9	3537.6
1950-58	4592.8	4694.5	4451.3	4714.6	4730.1	4795.0	4811.7	4733.8	4657.0	4708.1	4682.1	4692.7	4696.3	4699.4	4689.6	4706.2	4683.8	4467.0
1959-67	5669.5	5648.0	5621.4	5661.9	5685.9	5835.9	5831.2	5677.1	5619.5	5657.3	5639.1	5645.6	5650.3	5654.8	5641.4	5654.8	5641.3	5569.3
									FUEL, OIL AND REPAIRS EXPENSE (MILLION 1947-49 DOLLARS)									
1932-39	690.9	801.8	793.2	659.4	790.3	801.8	790.3	803.0	800.6	802.2	801.4	801.8	801.8	801.8	801.8	802.2	801.4	787.0
1940-49	1532.9	1454.9	1409.7	1295.5	1207.5	1470.0	1220.7	1460.6	1448.9	1455.5	1454.0	1456.3	1453.2	1455.2	1454.6	1457.1	1452.4	1440.4
1950-58	2436.1	2358.5	2263.0	2212.5	1922.7	2391.4	1938.7	2370.1	2346.3	2358.1	2358.8	2361.3	2354.6	2360.9	2355.8	2361.1	2355.2	2355.0
1959-67	2678.3	2711.4	2613.4	2575.1	2133.9	2752.2	2205.5	2723.5	2699.4	2708.7	2714.0	2713.8	2708.4	2717.9	2704.6	2711.5	2711.3	2727.2
									MISCELLANEOUS EXPENSE (MILLION 1947-49 DOLLARS)									
1932-39	1270.4	1296.9	1252.0	1156.4	1302.6	1296.9	1302.6	1302.9	1290.9	1299.7	1294.1	1296.9	1296.9	1296.9	1296.9	1299.7	1294.1	1228.3
1940-49	1475.5	1510.1	1398.5	1356.1	1518.5	1522.0	1527.0	1525.8	1493.9	1515.5	1503.8	1509.6	1510.6	1510.4	1509.8	1515.0	1504.3	1423.2
1950-58	2125.2	2205.8	2092.2	2061.5	2088.5	2225.8	2102.1	2225.7	2186.7	2212.4	2199.4	2204.9	2206.9	2207.1	2204.5	2211.4	2200.4	2112.0
1959-67	3180.8	3121.1	3102.4	2998.3	2769.4	3140.4	2777.0	3135.9	3106.5	3126.6	3115.6	3119.6	3122.4	3123.2	3118.9	3125.1	3117.0	3068.6
									INTEREST ON STOCKS (MILLION 1947-49 DOLLARS)									
1932-39	1084.3	1155.9	1135.8	1138.7	1158.2	1155.9	1158.2	1157.8	1154.1	1157.9	1154.0	1155.9	1155.9	1155.9	1155.9	1157.9	1154.0	1090.9
1940-49	1290.0	1269.5	1223.4	1234.3	1262.3	1212.3	1206.2	1272.7	1265.4	1274.1	1264.0	1268.3	1270.5	1269.5	1269.3	1273.0	1265.2	1150.5
1950-58	1378.6	1401.7	1356.9	1377.8	1366.1	1323.8	1300.0	1405.3	1398.3	1408.6	1394.6	1398.6	1405.3	1402.2	1401.1	1405.5	1398.2	1287.7
1959-67	1616.0	1587.4	1567.0	1565.8	1509.9	1383.1	1347.3	1591.2	1583.6	1594.9	1580.0	1583.0	1591.6	1588.5	1586.2	1590.6	1584.2	1480.0
									REAL ESTATE TAX EXPENSE (MILLION 1947-49 DOLLARS)									
1932-39	746.2	743.8	721.2	749.7	744.6	745.0	744.6	747.8	742.3	747.0	743.1	745.0	745.1	745.0	745.0	747.0	743.1	695.8
1940-49	625.1	647.0	606.0	648.0	644.0	653.7	654.1	646.9	637.2	644.7	639.2	642.0	642.5	642.5	641.9	644.5	639.5	609.0
1950-58	768.8	798.4	751.1	795.5	797.6	810.2	812.2	798.4	786.8	795.2	789.9	792.1	792.8	793.4	791.5	794.9	790.2	753.0
1959-67	1045.0	1029.0	1031.1	1039.4	1042.3	1073.1	1070.6	1041.9	1032.4	1039.4	1035.1	1036.7	1037.6	1038.5	1035.8	1038.8	1035.5	1013.2
									PRODUCTION EXPENSES (MILLION 1947-49 DOLLARS)									
1932-39	8732.3	10563.1	10301.1	10175.0	10584.4	10566.4	10584.4	10598.1	10535.2	10587.7	10545.4	10566.3	10566.5	10566.4	10566.4	10587.6	10545.5	9797.3
1940-49	15976.6	16001.4	15379.0	15294.2	15577.0	15792.3	15358.2	16076.6	15911.5	16038.3	15948.3	15988.4	16004.3	16000.8	15992.0	16030.3	15956.2	14538.7
1950-58	19117.5	19709.8	19195.0	19155.1	18733.2	19377.9	18424.9	19788.3	19626.7	19742.5	19668.6	19684.7	19725.7	19720.2	19688.0	19723.2	19690.2	18378.0
1959-67	21236.0	20901.7	20904.6	20508.9	19492.0	20296.4	18992.9	20962.8	20854.6	20933.8	20883.1	20881.5	20932.3	20933.2	20881.5	20908.2	20908.3	20018.6
									GROSS INCOME (MILLION 1947-49 DOLLARS)									
1932-39	17019.0	17831.1	16246.1	18142.0	17819.8	17831.2	17819.8	17945.5	17718.4	17852.6	17808.7	17834.7	17827.3	17831.0	17831.0	17856.3	17805.0	17867.9
1940-49	30398.3	29975.8	26136.9	30304.9	30294.1	30620.7	30814.5	30330.7	29612.0	30007.3	29936.3	30030.2	29910.8	29990.5	29959.1	30063.5	29873.0	30254.6
1950-58	30489.3	30238.0	25917.6	30522.4	30846.9	31286.2	31504.8	30710.8	29763.7	30303.6	30171.7	30314.7	30152.0	30273.8	30202.1	30380.7	30086.1	30825.3
1959-67	30909.6	30696.9	26137.8	30963.5	31667.8	32144.3	32034.5	31118.3	30290.4	30769.8	30625.2	30774.8	30624.7	30740.9	30653.0	30847.9	30553.1	31365.2
									NET INCOME (MILLION 1947-49 DOLLARS)									
1932-39	8286.7	7267.9	5945.0	7967.0	7235.4	7264.8	7235.4	7347.3	7183.2	7265.0	7263.3	7268.4	7260.9	7264.6	7264.6	7268.7	7259.5	8070.6
1940-49	14421.7	13974.4	10757.9	15010.7	14717.1	14828.4	15456.3	14254.1	13700.6	13969.1	13988.1	14041.7	13906.4	13989.7	13967.1	14023.2	13916.7	15745.9
1950-58	11371.9	10528.2	6722.6	11367.3	12113.7	11908.3	13079.8	10922.5	10137.0	10561.1	10503.1	10630.0	10426.3	10553.6	10514.1	10657.5	10395.8	12447.3
1959-67	9673.6	9795.2	5233.1	10454.6	12175.8	11847.9	13041.6	10155.5	9435.8	9836.1	9742.1	9893.2	9692.4	9807.7	9771.4	9939.7	9644.8	11344.5

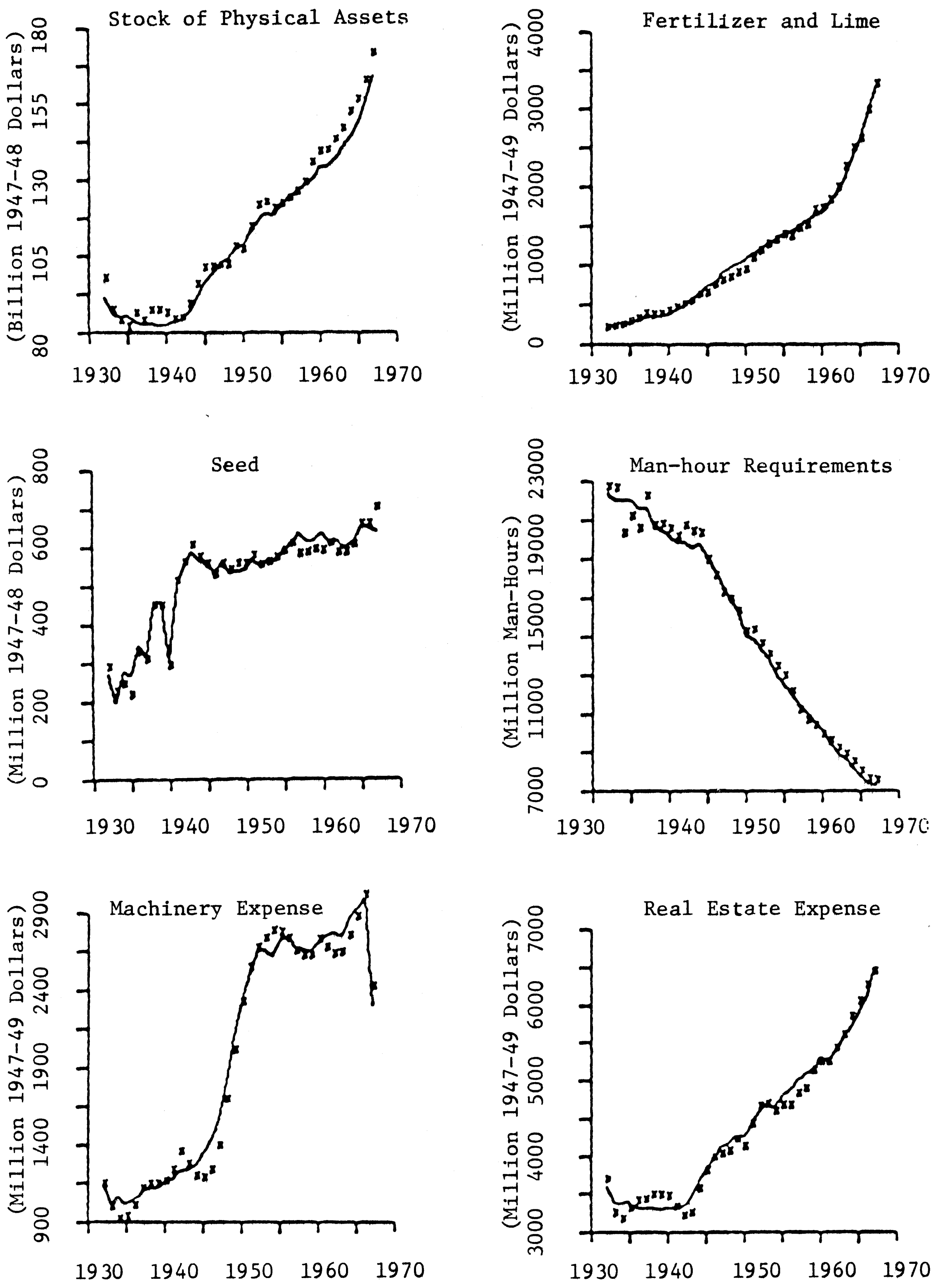

Figure 2. Actual values (x) and simulation estimates (-) of selected United States inputs and incomes, 1932-1967.

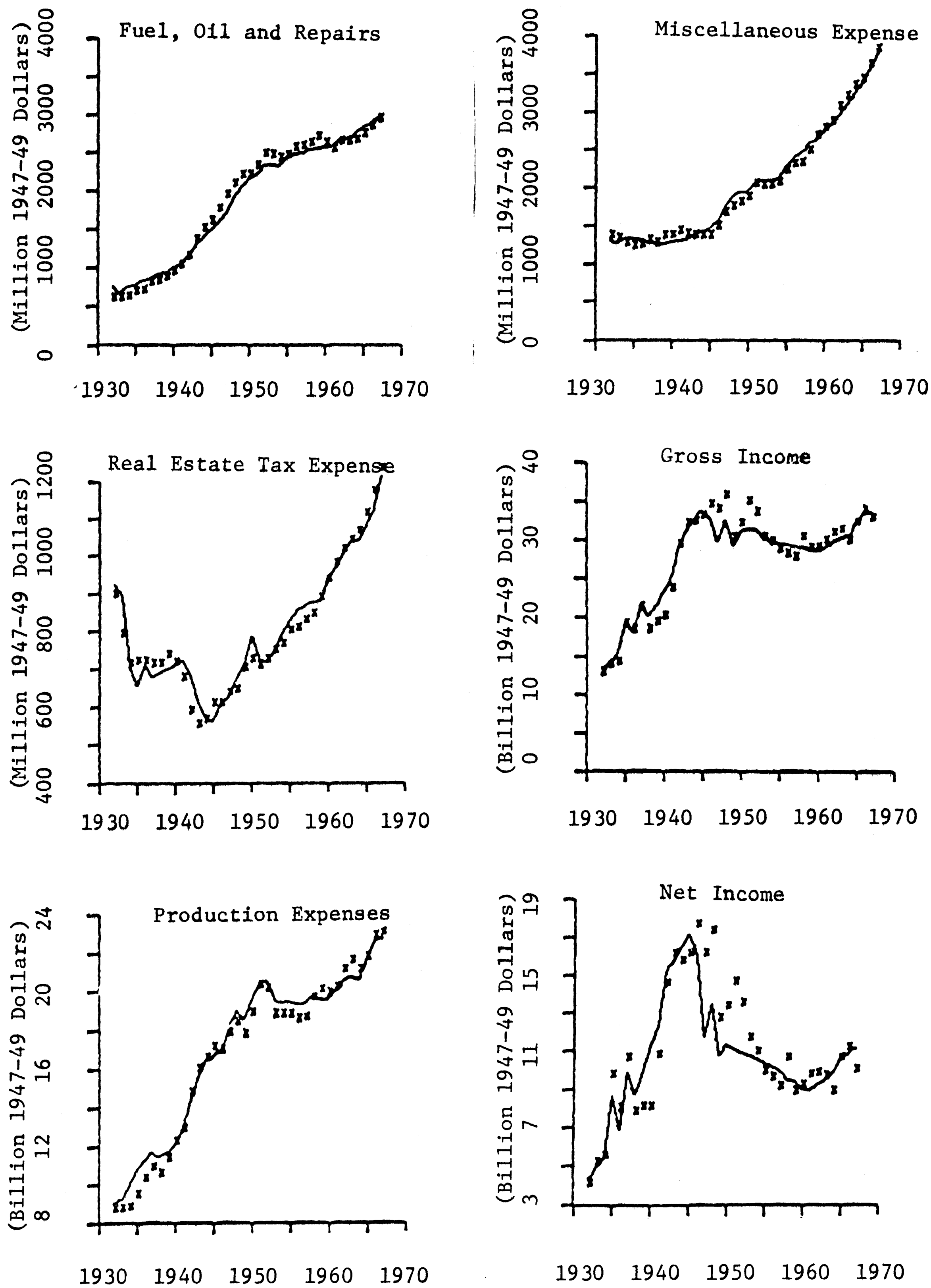

Figure 2 continued.

Simulation Results

Changes in certain exogenous data and selected parameters are now made in the model to gain knowledge on what would have occurred in the agricultural sector under alternative conditions. These "experiments" provide post-priori indications of the effects of different levels of government policy and other variables on resource use and farm income. Results of the historical simulations are also useful in evaluating the likely consequences of implementing new government policies in the future.

The results from seventeen simulation runs are reported. The first simulation, or validation run, was briefly discussed in the previous section. The results from the other simulations are presented here. Conditions simulated include: (a) the removal of government price and income support programs, (b) increases in input prices, (c) restrictions on production elasticities, (d) variations in commodity support prices, and (e) limitations on acreages. The variable levels generated in each of the simulation models will be compared to variable level estimates of the validation run rather than to actual data. To conserve space, the results will be reported and discussed for averages of at least eight years.

Free market (simulation 2)

To see how agriculture would have fared under free market conditions, all government policy variables are set to zero in simulation 2. The estimated results, assuming no price supports, no diversions of excess production, no acreage allotments or diversions, and no government payments, are reported for selected variables in tables 10 through 16 under column heading SIM 2. The tabulated estimates are variable averages for 1932-39, 1940-49, 1950-58, and 1959-67.

The initial or first-year response to the removal of government programs is an increase in crop acreage and production. As these additional supplies reach the market, crop prices decline. Inelastic demands cause prices to drop by a larger percentage than supplies increase resulting in lower gross incomes. Faced with lower prices and incomes, farmers begin to reduce production. Simulation results indicate this reduced production is not accomplished by taking land out of production, but rather by applying fewer resources to each acre. Reduced resource use is partially in response to lower crop prices, but capital limitations also play an important role. Typically, the level of resources used by farmers is not the quantity that sets the value of the marginal product for each resource equal to its price. While the reasons for this less-than-efficient use of resources are many, often times the equilibrium level of resource use is prohibited by capital limitations. The reduced incomes and lower land values in the absence of government programs decrease internally generated capital and erode farmers' borrowing base.[1] This

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[1]The model was modified slightly to allow the utilization of "feedback" information on gross income levels to aid in determining land prices. The land prices generated in simulation 1 are used as base data to calculate land prices in the other simulation models. The simulation 1 current-year price of land estimate for each crop is adjusted by a proportion of the difference between the simulation 1 estimate of the crop's gross income estimate for the previous year and the comparable gross income estimate in the simulation under consideration. To obtain the proportions, the price of land for each crop

continued

tightening of capital constraints reduces the quantity of resources farmers can afford. Farmers rely more on the nonpurchased inputs, such as land and labor, and less on fertilizer, pesticides, and more efficient machines in their production activities.

Even though production for most crops declines with the removal of government programs (after the second or third year), supplies are larger than will clear the market at prices that existed when the government programs were in operation. These lower prices depress incomes throughout the 1932-67 period of analysis. The assumed removal of acreage diversions and allotments causes acreage increases for feed grains, wheat, and cotton during the last period of analysis, 1958-67, to more than offset reductions in input use per acre. The resulting increases in supplies further depress prices and gross incomes during the 1958-67 period.

In contrast to the other crops, soybean production estimates in the free market model are above the validation run levels throughout the entire 1932-67 period. Lower prices for feed grains are translated into increased soybean acreages via the soybean acreage function. Over the 1932-67 period, the soybean production estimate is 6.4 percent higher, but the soybean acreage estimate is 35.5 percent above simulation 1 results. Less productive land would likely be drawn into soybean production in addition to the use of less resources per acre. The implied soybean yield per acre in

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footnote 1 continued from page was regressed on the one-year lag of the respective crop's gross income variable using observed data from 1930-67. The coefficient estimates associated with the lagged gross income variables for each of the crops became the proportions. The estimated coefficients on the lagged gross income variables were: .054 for feed grains, .024 for wheat, .074 for soybeans, .018 for cotton, and .083 for tobacco.

the validation run is 22.4 for the 1932-67 period, while the comparable average yield in simulation 2 is 17.7.

The number of livestock production units increases somewhat in response to lower feed prices. The index of livestock marketings is 4.7 percent higher than the validation run for the 1932-67 period, while the index of livestock prices declines 8.0 percent.

Crop price estimates under free market conditions are lower by 46.0 percent for feed grains, 29.8 percent for wheat, and 21.1 percent for soybeans for the 1932-67 period.

Gross incomes by commodities and for the entire agricultural sector are estimated to have been substantially lower in the absence of government programs. Gross income estimates for feed grains during the 1932-67 period declined 26.9 percent from the simulation 1 level. Cotton and tobacco gross income estimates show the largest percentage drop at 59.6 and 43.2 percent, respectively. Nationally, total gross farm income estimates average \$3.7 billion lower than the simulation 1 results during the 1932-67 period (\$27.5 billion and \$23.8 billion for simulations 1 and 2, respectively). Since total production expenses do not drop proportionally, annual net income estimates decline by nearly one-third from \$10.6 billion to \$7.3 billion on the average for the 1932-67 period.

National estimates for all of the resource-use categories are lower except for seed and labor. Estimated fertilizer and lime demand for the 1932-67 period is down 6.0 percent from the simulation 1 level, and during the 1940-49 period fertilizer and lime expenditures (in constant 1947-49 dollars) are 13 percent below the validation run estimates. Because of decreased machinery purchases and lower machinery stocks, machinery expense estimates are down 5 percent. The real estate expense, fuel, oil, and repairs expense, miscellaneous expense, interest on crop and livestock stocks, and real estate tax estimates range from 3.6 to 2.5 percent below simulation 1 results. The high complementary relationship between seed expense and crop acreages causes the seed expense estimates in the free market model to be above the validation run results.

Many proponents of returning agriculture to free market conditions contend that government programs have slowed the outmigration of farm labor to nonfarm employment and thus hindered needed resource adjustments. The results of this study indicate, however, that the outflow of labor from agriculture is larger with the historic farm programs in operation than would have occurred under free markets. The apparent reason for this rather surprising result revolves around capital limitations and other manifestations of uncertainty typically found in agriculture. Apparently, increased income and higher and more stable prices resulting from government programs have provided the capital and security efficient farmers have needed to substitute machines and other highly productive capital inputs for their own and hired labor (12, 31). To realize economies of scale associated with larger machinery, these farmers have expanded their operations by securing land operated by other farmers who have retired or transferred to off-farm jobs. As a result, agriculture uses less labor on fewer but larger farms. The magnitude of these changes appears to be greater than would have occurred in the absence of farm programs.

It seems clear that acreage diversion and price support programs of the federal government have accelerated the adoption of new production techniques, increased the use of fertilizer, and aided in the mechanization of agriculture. Simulation results suggest that this shift from labor to capital intensive techniques would have occurred without government programs but at a slightly slower pace.

Changes in input prices and production elasticities

Modern agriculture has been transformed from a labor to a capital intensive industry. Changes in the relative prices of labor and capital, technical development of capital items, increases in adoption rates, and possibly security provided by farm programs have caused farmers to use more capital and less labor in agricultural production. The decline in the real price of many capital inputs for agriculture has resulted from technological improvement and competition in firms and industries that produce these inputs.

In simulation 3 through 6, input prices and input production elasticities are altered from their observed values. Information on the influence of input prices and productivities on resource use, commodity prices, and incomes is very useful. Surpluses and low returns in agriculture have occurred because the productivity of resources used by producers has increased and the quantity of these resources used is large relative to the demand for agricultural products.

One method of reducing output is to reduce the quantity of resources devoted to agricultural production. Acreage allotments and diversions have been used to reduce the land input. But output does not decline in proportion to land withdrawn. Farmers usually take their less productive land out of production. More importantly, the capital and labor formerly used on the idled land is transferred to the remaining crop acres. Furthermore, payments made to farmers for idling land provides farmers with the wherewithal to buy more capital inputs. The result of these factors is that farmers apply the larger amounts of capital inputs to the nonidled land, causing the anticipated output reduction from the idled land to be offset by greater output from the remaining land.

Control of inputs has centered on land since land withdrawals are relatively easy to police. While agricultural programs could be directed at reducing the quantities of capital and labor used, quota systems on these inputs would be difficult to enforce. Reductions in the use of capital inputs could be accomplished indirectly by raising input prices. The government could levy taxes on the producers of capital inputs which would be passed along to farmers in the form of higher prices. Higher input prices would encourage the use of less capital inputs, thereby reducing production and increasing commodity prices, incomes, and resource returns.

Output increases could also be slowed by reducing investments in measures that increase farm resource productivity. Public financial support for researching and communicating new farm technologies could be reduced or even eliminated.

Increasing input prices and (or) slowing technological advance as a means of reducing production (or dampening production increases) and improving income have very serious drawbacks. Both conflict with the natural forces of economic growth. Agricultural policy should facilitate, not retard, long-run adjustments in the optimal mix of national resources used in farm and nonfarm sectors as well as encourage least cost resource use within the farm sector. Artificial increases in input prices and limits on technological progress are at odds with accepted national goals of economic growth and of providing consumers with desired goods at least resource cost.

Furthermore, at this point in time, attempts to slow technological advances would be less than completely successful. While at one time most of the research and knowledge dissemination was carried on by government agencies, most of these activities are now in the hands of private industry. But the fact remains that the initial investments in activities to increase the productivity of farm inputs originated in the public sector. The private sector utilized and enlarged the knowledge base generated within public institutions and agencies.

Technological progress influences the marginal physical productivities of farm inputs and hence the position and shape of agricultural production functions. For information purposes, simulation runs are made that assume the crop production functions derived for the 1932-39 period in this study had remained in use through 1967. The results of these simulations are discussed in the following sections. First, however, simulations which investigate the impacts of increased input prices on the agricultural sector are discussed.

Input prices increased by 10 percent (simulation 3): In this simulation all input prices that aid in determining the input demand levels are increased by 10 percent. Input prices used in the model are: price of machinery, price of fertilizer, price of motor supplies, price of farm supplies, and the prices of wheat and cotton seed. All prices are deflated by the implicit Gross National Product deflator and are in index form (1947-49 = 100). The price of farm supplies is employed in each of the commodity miscellaneous expense equations. The price of motor supplies appears in all of the fuel, oil, and repairs expense equations except for soybeans. Similarly, the price of fertilizer is used in each of the crop fertilizer demand functions with the exception of soybeans. Only the tobacco and cotton machinery purchases equations contain the price of machinery, while the seed price variables are specific to the wheat and cotton seed demand functions. The results of simulation 3 are reported in tables 10 through 16 under column heading SIM 3.

As expected, simulation results indicate that producers lower input usage and production in the face of higher input prices. Production estimates during the 1959-67 period are lower by 3 million tons for feed grains, 24 million bushels for wheat, 6 million bushels for soybeans, 500 thousand bales for cotton, and 7 million pounds for tobacco.

During the 1959-67 period, fertilizer and lime demands for feed grains, wheat, soybeans, cotton, and tobacco drop from their respective simulation 1 levels by the following percentages: 8.1, 7.9, 1.0, 2.1, 12.2, and 4.1. Nationally, fertilizer demand is $119 million, or 5.3 percent lower than the validation run estimate for the 1959-67 period.

The fuel, oil, and repairs expense and miscellaneous expense estimates are down by 5 and 4 percent, respectively, for the United States in the 1959-67 period. Livestock, cotton and tobacco, and fuel, oil, and repairs expense levels are 14, 27, and 19 percent lower, respectively, in 1959-67. Miscellaneous expenses decline by 6 percent for feed grains, by about 7 percent for wheat, cotton, and tobacco, and by 4 percent for livestock and soybeans.

Lower production estimates result in higher crop prices. The price of feed grains increases from $33.19 per ton in simulation 1 to $34.54 during 1959-67; wheat prices increase from $1.35 per bushel to $1.40 per bushel; soybean prices rise from $1.84 per bushel to $1.87 per bushel. Lower livestock production resulting from the increased feed grain prices causes the index of livestock prices to increase from 62.4 in simulation 1 to 63.1 in 1959-67. Because of lower capital input demand levels associated with higher input prices, total United States production expenses are lower by $410 million for the 1959-67 period compared to simulation 1 results.

With inelastic demands, the increases in commodity prices are proportionally larger than the reductions in commodity outputs. Hence, gross incomes are higher, although modestly. The average national gross farm income estimate for 1959-67 is up $289 million ($30,674.1 million in simulation 1 and $30,963.5 million in this simulation). Total net farm income increased from $9.8 to $10.5 billion or 7 percent.

Table 17 shows three price elasticity estimates for fertilizer, fuel, oil, and repairs expense, and miscellaneous expense for certain commodities. The first row of numbers for each input category uses the "everything else held constant" elasticity concept that is presented in all of the elementary economics textbooks. These static or short-run elasticity estimates are derived from the econometric equations presented earlier. For example, the feed grain fertilizer elasticity with respect to price is calculated by multiplying the coefficient of the price of fertilizer in the feed grain fertilizer equation by the ratio of the 1930-67 average price of fertilizer to the 1930-67 average level of feed grains fertilizer demand. The first row of elasticities under each input category indicates the percentage change in input demand associated with a 1 percent change in the input's own price, everything else held constant.

The numbers in the second rows under the input groupings are the "long-run" price elasticities of demand. These long-run elasticities again assume that output prices, technology, and the prices of all other inputs remain constant; however, time is allowed to elapse. The time that is needed to overcome entrenched habits, institutional and psychological resistance to change, and other barriers to immediate and complete adjustments in input usage to price changes is assumed to have elapsed. Long-run

Table 17. Estimated static, long-run and model elasticities of demand with respect to price for fertilizer and lime, fuel, oil and repairs and miscellaneous inputs for selected commodities[a]

	Livestock	Feed grains	Wheat	Soybeans	Cotton	Tobacco
Fertilizer and lime						
Static	--[b]	- .33	- .94	--[b]	-1.17	-1.03
Long-run	--[b]	-2.27	-2.36	--[b]	-2.17	--[c]
Model	--[b]	-1.79	-1.78	--[b]	-1.79	- .76
Fuel, oil, repairs						
Static	- .52	--[b]	-1.46	--[b]	-1.91	-1.57
Long-run	-2.49	--[b]	--[c]	--[b]	-2.12	--[c]
Model	-2.18	--[b]	-1.23	--[b]	-2.74	-2.25
Miscellaneous						
Static	- .68	- .72	-1.05	- .47	-1.02	-1.63
Long-run	- .82	-1.03	-1.39	-1.24	--[c]	--[c]
Model	- .85	-1.01	-1.17	-1.08	- .79	-1.20

[a]The static and long-run elasticities are computed from the econometric equations at the 1930-67 variable means. The "model elasticity" estimates are based on Simulation 3 results in which input prices were increased by 10 percent.

[b]Input price did not appear in the econometric equation (of course, the livestock model did not contain a fertilizer and lime equation).

[c]Long-run elasticity estimate could not be computed because the lagged input demand variable did not appear in the econometric equation.

input demand elasticities can be calculated from econometric equations that contain the lagged dependent variable as well as the input's price as explanatory variables. Subtracting the coefficient estimate of the lagged dependent variable from 1.0 gives the adjustment rate; that is, the proportion of the adjustment in input demand in response to a price change that occurs in one year. Dividing the static input demand elasticity by the adjustment rate yields the full or long-run response of input demand to a change in input price.

The results from simulation 3 provide us with a third measure of the responsiveness of input demand to changes in own price. The response of input demand to a change in its price derived from the simulation model not only allows lags in adjustment but also includes feedback influences on input demand resulting from changes in output price. The static and long-run elasticity estimates assume constant output price. In reality, output price will likely change. A reduction in the usage of a highly productive input, such as fertilizer, resulting from an increase in (fertilizer) price, lowers output. The lower output level stimulates the average price received by farmers and, with inelastic demand, gross income increases. The higher output price and the lifting of capital restraints, made possible from higher incomes, tend to increase input demand somewhat in succeeding years. Hence, the feedback influence of higher output price and incomes on input demand is allowed to operate in the simulator model.

Attempts to use simulation 3 results to estimate changes in the demand of a particular input associated with a change in price of that input are obstructed somewhat by the assumed changes in other input prices. We would rather keep other input prices constant and measure the direct and indirect effects of a change in the price of a particular input on the usage of that input. In the interest of economy and brevity, simulation 3 results are used. The response estimates are also biased somewhat because of the indirect influence that commodity price and incomes exert on input demands. Commodity price (lagged one year) enters the model primarily via the acreage function. The level of gross income (lagged one year) influences the level of machinery purchases and land prices. Estimates of machinery purchases are used to estimate machinery stock levels. The acreage and land price estimates are employed to estimate the value of land and buildings. The average stock of machinery and the stock of physical assets (the sum of average machinery and average commodity stocks and the value of land) are the variables that are used to help determine input demands. Hence, output price and incomes are not used directly in the input demand equations, but their influences are funneled in through the stock of machinery and physical asset variables.

The results in table 17 indicate that when the influence of commodity prices and incomes are taken into account, the net influence of a change in the price of an input on its usage is generally lower than the "long-run" estimate which assumes ceteris paribus conditions.

Input prices set at 1932-39 average level (simulation 4): In this simulation, input prices are again altered from their historic values. The input prices that were increased by 10 percent in the last model are held at their 1932-39 average levels in this simulation. The real prices of certain capital inputs declined substantially over the 1932-67 period. Reductions in prices of fertilizer, motor supplies, and farm supplies are the most striking. The 1932-39 average of the index of fertilizer prices (1947-49 = 100), deflated by the implicit GNP deflator, was 129.2 while in 1967 the index stood at 70.8. The 1932-39 average price indexes for motor supplies and farm supplies were 134.6 and 107.6, respectively, while in 1967 these prices had dropped to 85.9 and 77.4. The deflated index of machinery prices increased from the 1932-39 average of 114.3 to 128.3 in 1967. Wheat and cotton seed price indexes increased from their 1932-39 averages of 62.2 and 56.2 until the late 1940s or early 1950s and then declined again to 82.6 and 88.0, respectively, in 1967.

Simulation 4 investigates the impacts on agricultural resources, production and incomes, assuming that the historical increases in capital productivity had occurred but selected input prices had remained at their 1932-39 average level. Tables 10 through 16 contain the period averages for 1932-39, 1940-49, 1950-58, and 1959-67 of simulation 4 results under column heading SIM 4.

With the index of fertilizer prices held at its 1932-39 average, the quantity of fertilizer and lime demanded is substantially lower. Feed grain fertilizer and lime estimates drop by over one-third for the 1940-49 and 1959-67 periods and by nearly one-half during 1950-58. Wheat fertilizer and lime levels are one-half the simulation 1 estimates for each of the three periods. During the 1959-67 period, cotton fertilizer and lime estimates average 74 percent below simulation 1 results. The United States fertilizer and lime demand estimate for 1959-67 is down by 33 percent from the validation run estimate.

Fuel, oil, and repairs expense and miscellaneous expense estimates after 1940 are also considerably below simulation 1 estimates for certain commodities. For example, the level of wheat fuel, oil, and repairs expense declines by 38 percent during the 1959-67 period and wheat miscellaneous expense decreases by 17 percent. United States estimates are 19 percent lower for fuel, oil, and repairs expense and 13 percent lower for miscellaneous expense for the 1959-67 period as compared to simulation 1 results.

The reductions in use of these highly productive inputs reduces production for all crops during the last three periods. For 1959-67, feed grain production drops from 148.7 million tons in the validation run to 133.7 million tons or a decrease of 10 percent. Wheat production is 11 percent lower, soybean production is down 4 percent, and cotton production drops 24 percent for the last period of analysis.

Prices and gross incomes increase from 1959 to 1967. The average price of feed grains and average feed grain gross income for the period are up 20.5 and 2.3 percent, respectively. During this same period price and gross income increases for wheat, soybeans, and cotton are: 22 and 7 percent, 8 and 4 percent, and 74 and 24 percent, respectively.

The higher feed grain prices reduce the number of livestock production units by 1 percent for the 1959-67 period. The index of livestock prices increases by 3.7 percent and livestock gross income increases by $322 million above the simulation 1 estimate for that period.

For the nation, the decline in usage of operating inputs reduces total farm production costs by 8 percent during 1959-67. Total farm gross income increases by 4 percent and net farm income jumps from $9.8 billion to $12.7 billion.

Simulation results suggest that input prices could be manipulated as a means of reducing resource commitments in agriculture and, hence, as a means of decreasing outputs and increasing incomes. However, adjusting resource use through restricting capital input prices conflicts with economic efficiency considerations. Adjustments in resource use should encourage the displacement of resources that have a higher value marginal product in alternative uses [29]. Restrictions on prices of capital operating inputs causes the input mix to include less of the highly productive operating inputs and more labor. But it is the labor input that has the high value marginal product outside agriculture relative to its value at the margin in agriculture.

<u>Input production elasticities at their 1932-39 average level (simulation 5)</u>: In the last model (simulation 4), input prices were fixed at their 1932-39 level. In this simulation, historic trends in input prices are unaltered, but input production elasticities are held at their 1932-39 level. Hence, input demand levels generated in the simulation model are

channeled through the 1932-39 production functions for the entire simulation period.

Results from simulation 5 are presented in tables 10 through 16. Since the models used in simulations 1 and 5 are identical through 1939, the variable levels generated for these simulations are the same for the 1932-39 period. Production, price, and gross income estimates deviate substantially from simulation 1 results for the remaining periods, 1940-49, 1950-58, and 1959-67. During the 1959-67 period, feed grain production is lower by 50 million tons or by one-third than the simulation 1 estimate, cotton production is 50 percent lower, and soybean production declines by one-third.

These sharp declines in production push output prices to very high levels. The 1959-67 average price of feed grains in this simulation is \$55.65 per ton compared to \$33.19 per ton in simulation 1. Simulation 5 and simulation 1 prices for wheat, soybeans, and cotton during the 1959-67 period are: \$1.72 and \$1.35 per bushel, \$3.02 and \$1.84 per bushel, and \$.52 and \$.21 per pound, respectively.

With inelastic demand, the higher prices cause gross incomes to increase. For 1959-67, feed grain and wheat gross incomes increase 3 and 8 percent, respectively, and soybean and cotton gross incomes are up 11 and 22 percent, respectively.

Differences in the estimates of resources used in production in this model compared with the validation model are less dramatic. Nationally, the estimated levels of capital inputs used in agriculture are nearly the same as in simulation 1. It should be remembered that the data used to estimate the input equations were observed in an environment in which input productivities were changing. No adjustments were made in the structural coefficients of the input equations to reflect the absence of these changes in input productivities.

Results from this simulation imply that had the feed grain production functions, employed in the thirties, remained in use through the late sixties, 4 percent more land and about the same capital inputs would have been needed to produce a third less output during the 1959-67 period.

Technological advancements have enabled agriculture to provide ample quantities of food and fiber at relatively low prices. Had no technological improvements taken place since 1940, the demand for agricultural output would have shifted to the right at a faster pace than supply. Due to higher prices, inelastic demand and slightly lower production costs, total net farm income during 1959-67 would have been one-fifth larger (from \$9.8 billion to \$11.8 billion). Higher prices and incomes would have been achieved for farmers but at the expense of the consuming public. The "problem" would then not be (as it is now) how agriculture can share in the benefits from advanced technology in agricultural production, but rather how the general public, especially the poor, could be helped to secure a sufficient quantity of food and fiber. Even though the time trends and equation specifications that carry along advances in technology in the model are not eliminated, it is obvious that many more resources would be needed to provide a given level of agricultural output.

Input prices and production elasticities at their 1932-39 average levels (simulation 6): In simulation 4, input prices were assumed to have been at their average 1932-39 levels throughout the observation period. The last simulation held the input production elasticity estimates used in each crop's production function at their 1932-39 levels. In this simulation both input prices and input production elasticities for each crop are fixed at their 1932-39 average levels.

The changes in variable levels in this simulation as compared to simulation 1 results are to a large extent exaggerations of the changes in variable levels observed in the last two simulations. Production estimates are lower and price and income estimates are higher than simulation 5 results in which 1932-39 production functions were used but historic input prices were kept. Similarly, total levels of resource use measured in constant dollars are less than in simulation 4 with input productivities unaltered but 1932-39 prices assumed throughout. The resulting total farm net income estimates are the highest for any simulation model run. During the 1959-67 period, net farm income is up one-third from the simulation 1 estimate ($9.8 billion for simulation 1 and $13.3 billion for this simulation).

Changes in price support levels

Simulations 7 through 16 investigate the effects of different support price levels on resource use, production, price, and incomes for the model commodities and in aggregate.

The level of price supports is an important government policy variable. Government storage and price support programs are convenient vehicles to stabilize prices of farm products in the face of year-to-year variations in production. Excess production is diverted from the market in "good" years to be put back on the market in years in which production is short relative to demand. Price supports then tend to stabilize prices, based on average-weather crop levels.

The level of price supports can also be used to raise or lower the general level of farm prices. Raising crop prices by setting loan rates considerably higher than market prices is not without a cost. Farmers increase production, government stocks accumulate, and treasury costs mount accordingly. Furthermore, as the simulation results presented in the following sections suggest, the output-increasing effect of higher support prices moderates the intended increases in average market prices. Hence, a given percentage increase in support prices raises the average price received by farmers by a smaller percentage. The higher prices and production levels resulting from increased price supports increase gross receipts, but by a much smaller percentage than the percentage increase in loan rates.

Similarly, downward adjustments in support prices tend to reduce average market prices and gross incomes by a smaller proportion than the reduction in loan rates. The decline in production exerts upward pressure on market prices which offsets, somewhat, the reduced support prices.

In the simulation runs described in this section, no changes are assumed in the acreage allotments or diversions that accompanied price supports in certain years.

Ten percent increase in price supports (simulation 7): The estimated levels of selected variables, assuming that the price support rates for corn, wheat, soybeans, cotton, and tobacco are increased by 10 percent throughout the 1932-67 period, are reported in tables 10 through 16 under column heading SIM 7.

Estimated total farm gross income is 1.3 percent higher during the 1932-67 period than the simulation 1 estimate. Total production expenses are .4 percent higher, and net farm income increases from the simulation estimate of 10,577.7 to 10,861.7 or a 2.7 percent gain.

The percentage increases in commodity prices in simulation 7 over simulation 1 for the 1932-67 period are: 3.6 for feed grains, 2.5 for wheat, 2.1 for soybeans, 9.2 for cotton, 2.1 for tobacco, and .6 for livestock.

The higher prices, with slight increases in production, raise the commodity gross income estimates. Gross incomes during the 1932-67 period are higher by $31.0 million for feed grains, $49.1 million for wheat, $11.7 million for soybeans, $179.6 million for cotton, $40.0 million for tobacco, and $36.1 million for livestock. Government inventories, while not tables, increase 26 percent for feed grains and cotton and 16 percent for wheat over the observation period.

Higher commodity prices and incomes increase (with a lag) the level of input usage only slightly. Fertilizer and lime expenditures increase only one-half of one percent nationally during the 1959-67 period. The tobacco fertilizer and lime estimate is up 4.2 percent and cotton fertilizer increases 1.8 percent, but feed grain and wheat fertilizer demands are less than 1 percent higher. The estimate of fertilizer and lime usage for soybeans is down from simulation 1 results. The higher feed grain prices caused the model to predict a decline in soybean acreages over the 36-year period. Estimates for each of the soybean input categories are lower during part or all of the observation period. For the 1959-67 period, national expenditures on machinery fixed costs; real estate expense; fuel, oil, and repairs expense; miscellaneous expense; and real estate tax expense are about one-half of one percent higher than the validation run. Total man-hours of labor required and seed expense change negligibly.

Ten percent decrease in all price supports (simulation 8): The results from simulation 8, with price supports nine-tenths of the actual levels, are reported in tables 10 through 16 under column heading SIM 8. In terms of percentage change from simulation 1 estimates, the national variable estimates for simulation 8 are, for the most part, mirror images of simulation 7 results. Resource use, production, prices, and incomes for simulation 7 and 8 change by nearly the same percentage from simulation 1 results but in opposite directions. Simulation 8 estimates for total gross farm income and total net farm income are 1.3 and 2.7 percent lower, respectively, than the simulation 1 estimates for the 1932-67 period. United States resource expenditure estimates for the 36-year period average less than 1 percent lower for all input categories except seed, which remains nearly constant.

Commodity prices and incomes are lower with a 10 percent reduction in support prices. The average decline in prices over the 1932-67 period are: 3.8 percent for feed grains, 2.6 percent for wheat, 2.1 percent for soybeans, 9.3 percent for cotton, 2.1 percent for tobacco, and .7 percent for livestock. During this period, gross income estimates were down by \$32 million for feed grains, \$51 million for wheat, \$12 million for soybeans, \$174 million for cotton, \$38 million for tobacco, and \$38 million for livestock.

Corn support prices increased by 10 percent (simulations 9 and 10): In simulation 9, support prices for corn are increased by 10 percent, and in simulation 10 they are decreased by 10 percent. Model estimates for simulations 9 and 10 are reported in tables 10 through 13 and table 16 under column headings SIM 9 and SIM 10.

With corn support prices 10 percent higher, the feed grain price estimate averages 3.1 percent higher than the validation run for the 36-year period. Feed grain gross income increases by \$30 million.

Input usage increases for all feed grain input categories. During the 1932-67 period, simulation 9 estimates for fertilizer and lime, real estate, miscellaneous, and real estate tax expenditures are about 1.9 percent above simulation 1 estimates. Estimates for the other input categories, including seed expense, man-hours of labor, machinery fixed and operating expenses, and interest on stock, are up less than 1 percent. The higher input levels increase production by about 1 percent.

The number of livestock production units declines slightly because of the increased price of feed grains. Livestock prices increase by one-half of one percent and gross income from livestock sales increases by $30 million for the 1932-67 period. Wheat used for feed increases by 1 million bushels. Wheat gross income is up $600 thousand.

Decreasing the price supports for corn by 10 percent (simulation 10) reduces the average of 1932-67 feed grain prices from $40.11 in the validation run to $38.81 or 3.2 percent. The annual average feed grain gross income estimate drops by $30 million for the 36-year period.

Fertilizer and lime expenditures are $9 million below simulation 1 estimates. Reductions in the other input categories are also observed, and together the lower input levels cause production to decline by 1 percent. For the 1959-67 period, government inventories drop by over one-third, from 21.7 million tons in simulation 1 to 13.4 million tons.

The simulation model implicitly contains a supply elasticity for each crop. Input levels generated in the model are influenced by commodity prices and incomes. These input estimates are used via production functions to estimate output. Hence, we can trace the effects of a crop price change on production by way of the changes in input usage. The feed grain supply elasticity estimates reported in table 18 are derived by first calculating the average percent change in production and the average percent change in price of simulation 9 (simulation 10) estimates from simulation 1 results for the 36-year period. Then the percentage change in production is divided by the percentage change in price for the respective simulations. The average responsiveness of input demands to changes in crop prices is estimated similarly. The input demand elasticities with respect to feed grain prices reported in table 18 are calculated by dividing the percent change in input levels by the percent change in feed grain prices.

Table 18. Estimated supply and cross input demand elasticities with respect to feed grain prices implied from results of simulations 9 and 10[a].

Category	Sim. 9	Sim. 10
Supply elasticity		
Production	.313	.201
Cross input demand elasticity		
Fertilizer and lime	.619	.610
Seed	.257	.260
Labor	.143	.146
Machinery	.127	.124
Real estate	.622	.604
Fuel, oil, repairs	.065	.065
Miscellaneous	.521	.508
Real estate taxes	.616	.598

[a]Elasticity estimates are calculated by dividing the percent change in variable quantity by the percent change in feed grain price. The elasticities measure responsiveness to increases in feed grain prices observed in simulation 9 and to decreases in feed grain prices observed in simulation 10.

The supply elasticity of feed grains is calculated at .3 with higher feed grain prices and .2 with lower prices. Using results of simulation 9, the fertilizer and lime cross price demand elasticity with respect to feed grain price, indicates that a 1 percent increase in price of feed grains would increase fertilizer and lime quantity by .6 percent.

Wheat support prices changed by 10 percent (simulation 11 and 12): The estimated levels of selected wheat variables, with wheat price supports increased by 10 percent and with wheat price supports decreased by 10 percent, are presented in table 12 under column headings SIM 11 and SIM 12, respectively. Changes in livestock, feed grain, soybean, and national variables can be observed for these simulations in Tables 10, 11, 13, and 16.

With wheat support prices increased by 10 percent, the average price of wheat for the 1932-67 period increases from $1.47 per bushel to $1.51 per bushel or about 2.5 percent. Gross income is up $49 million.

Machinery purchases increase by 1.5 percent due to higher incomes. Machinery fixed cost and operating expenses are higher by about $2 million each. Increases in acreage of one-half of one percent push real estate expenses and taxes upward by $2.5 million and $1 million, respectively. Miscellaneous expense increases by 1.2 percent over simulation 1 results for the 36-year period. Fertilizer, seed, labor, and interest on stocks estimates also increase, but by very little.

Production of wheat increases by 8 million bushels. With higher wheat prices, the model estimates reduced feed grain acreages, feed grain input levels, and feed grain production. Feed grain prices increase by one-half of one percent, and feed grain gross income estimates are $2 million dollars higher.

Results from simulation 12, in which wheat support prices are reduced 10 percent, show a decline in wheat prices of 2.6 percent and a 3.4 percent drop in wheat gross income.

The lower price estimates cause (with a lag) wheat acreage to decline, while lower gross income estimates slow increases in machinery purchases as compared to the validation run. These lower estimates set the stage for reductions in machinery and real estate related expenses. The percentage changes in the acreage, machinery, and real estate variables are nearly the same as in simulation 11 but in the opposite directions. Estimated levels for the other input categories also decline, roughly by the same proportion as they increased in the last simulation.

Government inventories decrease by 12 percent with a 10 percent reduction in wheat price supports, or 57 million tons on the average over the 1932-67 period.

Table 19 contains estimates of wheat supply elasticity with respect to wheat prices and estimates of cross input demand elasticities based on the results of simulations 11 and 12.

Soybean price supports changed by 10 percent (simulations 13 and 14): Model results from increasing soybean price supports by 10 percent and decreasing them by 10 percent are reported in tables 10 through 13 and table 16 under column headings SIM 13 and SIM 14.

While a 10 percent increase in supports increased soybean prices only 1.5 percent over the 36-year period, soybean acreages, resource use, and production were stimulated proportionally more than price. During the 1932-67 period, acreage and seed expense estimates increase by 1.5 percent. The remaining input categories increase between 2 and 3 percent except the fertilizer and lime input, which is 10 percent higher. The average annual

Table 19. Estimated supply and cross input demand elasticities with respect to wheat prices implied from results of simulations 11 and 12[a]

Category	Sim. 11	Sim. 12
Supply elasticity		
Production	.316	.315
Cross input demand elasticities		
Fertilizer and lime	.352	.354
Seed	.210	.211
Labor	.040	.039
Machinery expense	.555	.565
Real estate expense	.579	.577
Fuel, oil, repairs	.401	.408
Miscellaneous expense	.486	.485
Real estate taxes	.628	.619

[a]Elasticity estimates are calculated by dividing the percent change in variable quantity by the percent change in wheat price. The elasticities measure responsiveness to increases in wheat prices observed in simulation 11 and to decreases in wheat prices observed in simulation 12.

production estimate is 7 million bushels above the validation run or a 2.1 percent increase. Higher prices and more output resulted in a 3.5 percent increase in soybean gross income ($24 million).

Simulation 14 results also indicate the apparent responsiveness of soybean acreage and resource use to changes in soybean prices. Assuming a 10 percent reduction in soybean price supports, soybean prices decline by 1.5 percent or only three cents per bushel. Again, the cumulative effects of this modest but sustained price decline over the observation period on resource use are substantial. Fertilizer and lime expenditures are down 11.3 percent on the average. Machinery fixed cost and operating expenses are down over 2.5 percent, and real estate expense tax estimates decline 3 percent. The other input estimates are from 1.5 to 2.0 percent lower.

Production declines by 8 million bushels or 2.2 percent for the 36-year period. The reduction in price supports decreases soybean gross income by $24 million or by the amount soybean gross income increased with the higher soybean price support assumption.

Corn and wheat support prices changed by 10 percent (simulations 15 and 16): Previous simulation models have assumed changes in the price support levels of all model crops and changes in price support for corn, wheat, and soybeans separately. In simulation 15, the support prices of two crops, corn and wheat, are raised 10 percent; in simulation 16, corn and wheat support prices are decreased by 10 percent. The model estimates for selected feed grain and wheat variables are presented in tables 11 and 12. Feedback influences from variable changes in the feed grain and wheat sectors on livestock and soybean variable levels are tabulated in tables 10 and 13.

With corn and wheat price supports up 10 percent, feed grain prices increase $1.44 per ton above simulation 1 estimates. This 1932-67 period average price increase is 20 cents per ton higher than simulation 9, in which only corn price supports were higher. Higher wheat supports along with higher corn support prices tend to dampen the feed grain acreage increases that are predicted in simulation 9. Lower feed grain acreage estimates and smaller increases in the capital inputs applied to the land cause feed grain production to be 400 thousand tons less than in simulation 9 but 600 thousand tons more than in the validation run. With production lower and with less substitution of wheat for feed grains in livestock rations than in simulation 9, the 20 cents per ton increase in feed grain price results. The feed grain gross income estimates average 1 million dollars higher during the 1932-67 period than in simulation 9.

The wheat variable levels are virtually unchanged from the levels observed in simulation 11, which assumed a 10 percent increase in only wheat support prices.

The depressing effects on soybean acreage, resource use, and production observed in simulation 9 (with only corn supports increased) are also present in this simulation. The relative magnitude of the coefficient for the feed grain price variable in the soybean acreage function makes the soybean sector especially sensitive to changes in the feed grain sector. Since the farm machinery and technology sets used to produce feed grains and soybeans are similar, farmers likely devote more land to feed grains and less to soybeans as feed grain price rises relative to soybean price. However, the cross elasticity of soybean acreage-use with respect to feed grain price is probably much lower than implied by the model (which is greater in absolute value than one).

The tabulated results of simulation 16, with corn and wheat price supports decreased by 10 percent, show that feed grain resource-use and production do not decline by as much as when only corn support prices are reduced by 10 percent (simulation 10). While the differences are slight, the lower wheat prices generated in this simulation moderate the predicted reduction in feed grain acreages of simulation 10 and, subsequently, the resource demand estimates are also above their respective simulation 10 levels. Hence, feed grain production is above simulation 10 estimates but is about one-half of one percent lower than simulation 1 results in each of the four periods tabulated. The higher feed grain production estimates compared to simulation 10 cause feed grain prices to be below the simulation 10 price estimates. With inelastic feed grain demand, feed grain gross income is $1.5 million lower than in simulation 10 for the 36-year period.

Again, the wheat variable estimates in this simulation, with corn and wheat supports lower, are substantially the same as the simulation results in which only wheat support prices were decreased (simulation 12).

Feed grain acreage set at 100.0 million acres and wheat at 50.0 million acres (simulation 17)

In this simulation, feed grain acreages are held at 100.0 million acres and wheat acreages are fixed at 50.0 million acres throughout the simulation period. The feed grain acreage assumption represents a 28 percent reduction in feed grain acreage during the periods 1932-39 and 1940-49, 25 percent fewer acres during the period 1950-58, and 8 percent fewer acres over the 1959-67 period. The assumed 50.0 million acreage level for wheat is also well below average observed wheat acreages for the 1932-39, 1940-49, and 1950-58 periods (from 16 to 22 percent below). The estimates for this simulation are reported in tables 10 through 13 and table 16 under column heading SIM 17.

Holding feed grain acreage to 100.0 million acres during the 1932-39 period causes feed grain production to drop from the simulation 1 estimate of 83.0 million tons to 61.9 million tons. For 1950-58, the simulation 1 and simulation 17 feed grain production estimates are 120.1 and 101.4

million tons, respectively. From 1958-60, actual feed grain acreages were at about 130 million acres, but with the advent of the feed grain program in 1961, feed grain acreages were below 108 million acres from 1961 to 1967 and below 100 million for 1964-66. Hence, restricting feed grain acreages to 100.0 million acres reduces the 1959-67 production estimate by only 7 percent, a smaller proportion than for the other periods.

The declines in feed grain production boost feed grain prices considerably from 1932 through the fifties. For 1932-39, the price of feed grains jumps from the validation estimate of \$37.54 to \$56.85, or a 51 percent increase. The feed grain estimates for the 1940-49 and 1950-58 periods are 30 percent above simulation 1 results. The average feed grain price over the entire 36-year period is 31 percent higher than the comparable simulation 1 estimate.

Since with inelastic demand, prices increase by a larger percentage than production declines, gross income increases somewhat throughout the observation period. The 1932-67 average feed grain gross income estimate is up \$67 million or 4 percent.

Resource expenditures are lower for feed grains except for the machinery related expenses. Fertilizer and lime expenditures are lower by 20 percent. Seed expense, man-hours of labor required, and miscellaneous expenses are down by 33 percent, 26 percent, and 16 percent, respectively, for the 1932-67 period. The higher feed grain price and gross income estimates hold machinery purchases, machinery stocks, and machinery expenses at their simulation 1 level even though acreages are lower. Hence, the simulation model indicates that over the 36-year period the cumulative effect of higher incomes generated from feed grain production, with acreage held at 100 million, would have enhanced the substitution of machinery for labor in feed grain production.

Setting wheat acreage at 50 million acres throughout the simulation period is a less severe assumption than constraining feed grain acreage to 100 million acres. Over the 1932-67 period actual wheat acreage was 59.2 million or about 15 percent higher than the 50 million acre assumption.

Because of higher wheat prices and gross income estimates, the reduction in the levels of inputs used for wheat production does not drop by as large a proportion as acreage. During the 1932-67 simulation period, wheat production declines by 7 percent but wheat acreage is 15 percent below the simulation 1 acreage estimate. None of the input levels decrease by as much as acreage over the 36-year period except labor, which declines by 19 percent. Again, the results from the simulation model suggest that the resource mix would have included a larger percentage of capital inputs and less labor had wheat acreage been limited to 50 million acres during the 36-year period.

It should be emphasized that the labor estimates are man-hour requirements to produce the respective crops. The changes that would have occurred in the number of farm workers on farms would have undoubtedly been less than the changes in man-hour requirements would indicate. However, the continuation or even acceleration of the farm mechanization process would have put pressure on farmers to expand farm size to realize the economies of larger farm machinery. Also, the higher returns in agriculture may have encouraged nonfarm corporations to buy up farm land and to operate it with fewer farm workers than originally occupied the land. Finally, if land from entire farms was "rented" by the government to keep feed grain and wheat acreages down, many of the affected farmers would have left the farm work force and taken nonfarm employment.

The higher feed grain price estimates decrease the number of livestock production units on farms. The reduced livestock supplies increase livestock prices by 6 percent and livestock gross income by 2 percent during the 1932-67 period. Total production expenses for the United States for 1932-67 decline by 6 percent while total farm gross income increases by 1.5 percent. Total net farm income is up $1.5 billion or 15 percent for the entire period.

Summary

An econometric simulation model is developed in this study which causally links resource use, production, price, commodity disposition, and income for major agricultural commodities. Based on this quantitative model, the implications of changes in selected variables on resource use, output, and income are investigated for individual commodities and United States agriculture as a whole.

The simulation model has submodels, or blocks of equations, for livestock, feed grains, wheat, soybeans, cotton, and tobacco. The equations in each commodity submodel sequentially depict the commodity's production cycle from acreage planted, to level of resource use, to production, to price, to commodity disposition, and finally to gross income. The lag between resource commitments and realization of output in agriculture permits this sequential or recursive structure. To form the complete simulation model, the blocks or commodity equations are brought together in such a way as to preserve the recursive structure of the model. Equations are included at the end of the simulation model to "build up" variable estimates for the entire agricultural economy.

The results of 17 simulations are reported. Conditions simulated include: (a) the removal of government price and income support programs, (b) increases in input prices, (c) restrictions on production elasticities, (d) variations in commodity support prices, and (e) limitations on acreages.

Not unexpectedly, farm prices and incomes decline substantially in the absence of government farm programs. For example, over the 36-year observation period, feed grain prices average 46 percent below the feed grain prices in the validation run--a simulation of the agricultural economy with government commodity price and income supports absent from the economic environment. Total net income in agriculture declines by nearly one-third. Lower prices and incomes dampen the level of capital inputs used in agricultural production. Total fertilizer demand under the free market assumption is down 6 percent during the 1932-67 period compared with the validation run. Smaller proportional declines are noted for the other capital input categories. The depressing effect of lower commodity prices on acreage is more than offset by acreage increases resulting from the removal of acreage allotments and diversions. Hence, removing the influence of government price and income support programs and associated acreage restrictions resulted in fewer capital inputs being applied to more acres.

Simulation results indicate that more, rather than less, labor would have been engaged in agricultural production without government programs. The implication is that without government price and income support programs, farmers would have had less incentive and financial resources to purchase labor-saving capital inputs during 1932-67 period. The results of the free market simulation in this study and similar findings by Tyner and Tweeten [33] suggest that acreage diversion and price support programs of the Federal Government have accelerated the substitution of capital for labor in agricultural production.

Simulation Models 3 through 6 investigate the effects of increased input prices and altered levels of input production elasticities on agricultural resource demand, production, and incomes. The level of agricultural production is a function of quantity and productivity of inputs used in agriculture. Surpluses and low returns in agriculture have occurred because the productivity of resources used in agriculture has increased and the quantity of these resources used is large compared to the demand for farm products. Improvements in farm prices, incomes, and resource returns could be achieved by reducing the resources committed to agriculture and (or) slowing technological advance. One way to dampen the use of resources in agriculture would be to raise their prices. In simulation 3, the real input prices used in the model were increased by 10 percent. In simulation 4, the downward trends in the real prices of capital inputs between 1932 and 1967 are ignored and all input prices are set at their 1932-39 averages. With higher input prices, input demands decline, resulting in lower production levels and higher prices and incomes. For example, with a 10 percent increase in real input prices, average feed grain production estimates over the 1932-67 period decline from 115.4 million tons in the validation run to 111.4 million tons. The average price of feed grains over the 36-year period increases $3.20 per ton, while the estimate of the gross receipts from the sale of feed grains increases by $23 million. Total gross farm income increases about 1 percent during the 1932-67 period.

With input prices fixed at their 1932-39 levels, resource use and production declines are substantial, especially in the latter part of the 36-year observation period. During the 1959-67 period, fertilizer used for feed grains and wheat declines by one-half, while national fertilizer usage is down by one-third during this period compared with the validation run. Expense estimates for other operating inputs, such as fuel, oil, and repairs expense, and miscellaneous expense, are also down. The resulting lower production estimates increase commodity prices and incomes. With production expenses and gross income both measured in 1947-49 dollars, the average annual net farm income estimate for the 1959-67 period increases from $9.8 billion to $12.7 billion.

Simulation models 5 and 6 assume that the estimated crop production functions for the 1932-39 period remain in use through 1967. In addition, input prices are held at their 1932-39 averages in simulation 6. Under these extreme conditions, production estimates decline sharply. The resulting higher prices push total net farm income up by one-fifth during the 1959-67 period when historical input prices are used and by one-third when real input prices are held at their relatively high 1932-39 levels. Obviously, agricultural policies that increase input prices and (or) slow technological advance would be effective in increasing farm prices and incomes.

The sensitivity of the levels of resource use, commodity prices, and incomes to changes in the crop price support levels is investigated in simulations 7 through 16. Support prices for each of the model crops are increased by 10 percent in simulation 7 and decreased by 10 percent in simulation 8. In simulations 9 through 16, price support levels are changed for only one or two crops in any particular simulation run. Simulation results indicate that a given percentage increase in crop price support levels raises average market prices by a smaller percentage. For example, increasing price supports for all model crops by 10 percent over the 1932-67 period results in the following average percentage market price increases: 3.6 for feed grains, 2.5 for wheat, 2.1 for soybeans, 9.2 for cotton, and 2.1 for tobacco. Annual farm gross income increases an average of 1.3 percent during the 36-year period compared with the base simulation. Production expenses increase by .4 percent and net farm income is 2.7 percent higher than the comparable 1932-67 averages in the validation run.

Simulation results suggest that the intended price and income benefits of raising price support levels are partially dissipated without added acreage or other supply controls. In response to higher support prices, farmers increase production. This increased production exerts downward pressure on market prices which partially offsets the higher support rates.

Restrictions are imposed on feed grain and wheat acreages in simulation 17. Annual acreages used in feed grain and wheat production are fixed at 100 and 50 million acres, respectively, for the entire 1932-67 period. With these restrictions on acreage, feed grain production during the 1932-39 period declines by one-fourth. Feed grain prices increase by 50 percent in the 1932-39 period and average 30 percent higher for the entire 36-year period. Wheat prices increase 24 percent in the first analysis period and average 14 percent higher over the 1932-67 period. Feed grain and wheat labor requirements decline by 26 and 19 percent, respectively, during the 1932-67 period compared to the base simulation. Declines are also noted for other input categories except for the machinery-related inputs. With higher prices and incomes, machinery purchases for use in feed grain and wheat production remain nearly unchanged from the validation run, even though acreage and production levels and the use of other resources decline substantially.

Perhaps the most striking result from the simulation analysis is that government policies which increase farm prices and incomes do not "hold" labor in farming but rather encourage the substitution of highly productive capital inputs for labor in agriculture. The implication is that the rate at which needed resource adjustments occur in agriculture is influenced to an important extent by the ability of individual farmers to finance the use of capital inputs and the prospect of being able to do so in the future. Apparently, agricultural policies that increase incomes and stabilize prices facilitate the increased use of highly productive capital inputs and as a result diminish labor requirements. Conversely, actions that lower farm incomes tighten capital constraints and aggravate maladjustments in resource use.

Limitations

Published input data for the individual commodities were generally unavailable. The estimation procedures used to allocate specific expense for all of agriculture to specific expense for individual commodities are outlined in Ray (23). Input-output studies, discussions with officials of the Farm Production Division of the United States Department of Agriculture, cost and return studies, and other sources were utilized to construct and check the various commodity input series. It is unknown how seriously inaccuracies in commodity input data affected the simulation results, but the fact that less-than-perfect data were used should be kept in mind when reading and interpreting the results of this study.

The economic model developed in this study in only one of many model formulations that could be used to portray the resource and output structure of United States agriculture. Other model formulations may better predict the actual time path of the endogenous variables. For example, the inclusion of weather variables in acreage equations may have improved the acreage estimates generated from the model. Also, a revised model should include more variables to link together the commodity submodels. The sensitivity of the livestock sector to changes in feed grain production and price is probably underestimated in the model used in this study. Additional use of feed grain production and price variables (lagged one year perhaps) in the livestock equations might add realism to the model. However, in other cases the magnitude of influence that a related commodity variable has on a variable of a particular commodity may need to be moderated. For example, the feed grain acreage estimate is slightly more sensitive to a given percentage decline in the price of wheat than to the same percentage increase in the price of feed grains.

The level of aggregation in this model is not as great as the national models of Tyner and Tweeten [33] and Lin [17], but it is still substantial. The farmer responsiveness to economic stimuli is not homogeneous within commodity groups but differs from one farm size to another and from one geographical location to another. Also, the commodity groupings themselves contain heterogeneous outputs.

Concluding Remarks

Ideally, a policy simulation model of the agricultural industry should serve as an econometric map of the agricultural economy within the framework of the total national economy. The interactions of the commodity and resource markets within the agricultural sector should be represented, as should the lines of influence between the agricultural sector and the national economy. The structural relations should incorporate government policy variables in sufficient detail that a broad range of economic policies can be simulated. The model should be capable of analyzing not only the effects of an agricultural policy change on the area of its immediate application but also the effects on related agricultural commodities, the entire agricultural sector, and the economy as a whole. The relatively unsophisticated model presented in this study is viewed as an intermediate step in the development of such a definite model of the agricultural sector.

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